On Vital and Medical Statistics

The Cartwright Lectures, delivered before the Alumni Association of the College of Physicians of New York in November, 1889

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ON VITAL AND MEDICAL STATISTICS.[1]

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Lecture I.

I propose in these lectures to speak of vital and medical statistics, and of some of their relations to each other and to scientific and practical medicine and sanitation. The discussion will include such points as, character of the data required; methods of obtaining them by the census, by registration, and in other ways; relations of physicians to this kind of work; methods of compilation and forms of publication; the best existing sources of such data; and some of the more common fallacies in drawing conclusions from the data as ordinarily published.

These and other points will be considered in their practical application to certain questions which, I hope, may be of interest to you, both as citizens and as physicians—as, for example: Is the average longevity of man in civilized countries increasing? What data are required to practically judge of the relative healthfulness of different localities, or of the same locality at different times? What are the relations of certain forms of disease to race, to climate, to locality, to occupation? What is the relative tendency to increase of population in this country in the white and colored races? What is the statistical evidence with regard to improvement in practical therapeutics as arrived at from hospital data, from death-rates in obstetric practice, etc.?

Statistics, and discussions of statistical methods are, as a rule, dry and uninteresting subjects, and it is with very considerable doubt and hesitation that such a topic has been selected for these lectures. I have no new discoveries to announce, and those who are practically familiar with statistical research will find some of my statements rather elementary; but the subject is not one which lies within the ordinary range of medical studies, the data are widely scattered in literature, and I hope, at least, to be able to remind you of some of the numerous points which you may have once known, but which may have been forgotten owing to the pressure of other studies and duties.

Statistics are somewhat like old medical journals, or like revolvers in newly opened mining districts. Most men rarely use them, and find it troublesome to preserve them so as to have them easy of access; but when they do want them, they want them badly.

The use of statistics may be compared to that of the microscope or the spectroscope, as pointed out by Mr. Hooper.[2] He says:

"It is found convenient to speak of the science of Spectrum Analysis, and of Microscopical Science, because complicated scientific instruments require that their users should understand them and be able to adjust them, and the knowledge which enables the operator to use his instrument and put it in order is important enough to be termed scientific. In this sense it might be possible to speak of a Science of Statistics. The knowledge suitable for the purpose of practising the art of Spectrum Analysis covers a wide field, necessitating a study both of the instrument itself and the phenomena which it reveals; and the same may be said of the knowledge needed for successfully practising the art of statistical analysis, and in this sense this knowledge may be termed scientific"

If we choose to accept the definitions of French, German, and many English writers, the term will include a large part of sociology.

Circumstances have made it necessary for me to endeavor to ascertain the character and amount of the statistical data which have been published, and which are available for those who wish to make special studies of the relative frequency of certain diseases, deformities, or disabilities; of their causes and results, especially as to mortality; or of the relations which exist between disease and death, and such conditions as sex, age, race, soil, climate, occupation, etc.; and in the course of this investigation it has seemed to me that many physicians are not as familiar with statistical methods, and with existing sources of information relating to vital statistics, as it is desirable that they should be to enable them to judge properly the value of the arguments and conclusions presented by those who make use of such data, even though they themselves may have no desire or intention to use statistical methods of research.

There are many fallacies and errors connected with vital and medical statistics as ordinarily collected and used, and it is highly desirable that the physician should be aware of the more important of these, since he is constantly appealed to for decisions as to their true significance and value. "It is as easy to tell lies with figures as with words, and bigger ones;" but while we occasionally meet with deliberate falsifications of the records, made for the purpose of magnifying or diminishing the apparent mortality or prevalence of a particular disease in a given locality, or to maintain an anti-vaccination thesis, these are not so frequent as are the errors of involuntary misstatement and misinterpretation into which those not familiar with methods of collecting and tabulating statistics are so liable to fall. Those who are not familiar with the methods of obtaining and compiling statistics of this kind are apt to be either unduly credulous or unreasonably sceptical as to their real use and value—to use the first figures which come to hand, and thence derive conclusions which are not warranted, or to reject the plain teaching of carefully compiled statistics in favor of general assertions which have no firm foundation, but which are in accord with preconceived opinions. My experience with those seeking statistical data is that the majority begin by looking for those data which are in favor of some particular conclusion with which they commence, rather than by selecting data with reference to their probable completeness and accuracy, and accepting the conclusions which may be legitimately drawn from them, whatever they may be.

Those who are engaged in the collection and compilation of official mortality and vital statistics are often at first the most sceptical as to their accuracy and utility, for their attention is so frequently and forcibly drawn to errors in the individual data that they conclude that the whole mass is unreliable; and the difficulties in the way of obtaining complete and reliable figures are seen to be so great that they incline to give up the whole matter in de-

[1] The Cartwright Lectures, delivered before the Alumni Association of the College of Physicians of New York, November, 1889.

[2] The Method of Statistical Analysis. A paper read before the Statistical Society of London, by Wynnard Hooper, B.A., January 18, 1881. Statistical Society of London, Journal, vol. xliv., p. 31.

spair. Continued study of the subject, however, shows that many valuable conclusions or suggestions can be derived from imperfect data, and that in large masses of figures the errors either tend to neutralize each other, or to produce a constant effect in one direction which can be calculated and allowed for, so that those who have had the greatest experience are most convinced of their value. It is true that, in statistics, the inferences cannot be more accurate than the data on which they are founded, but we do not look for scientific exactness from them so much as for an estimate of probabilities.

The methods which we have for advancing our knowledge of the laws of human life, of the causes of abnormity, disease, and death in man, and of means of sanitation or therapeutics, may be grouped into two classes, viz., observation and experiment—which, however, are often combined.

In the experimental method we seek to make a direct test of the variation of one particular condition, or set of conditions, upon the living organism, all other conditions being kept uniform as far as possible. Some such experiments can be made on man, but the greatest number of the problems which we may hope to solve by this method, and among these the most important, can only be approached by experiments on the lower animals. Within the last twenty years experimental physiology and pathology have made great advances, and these methods, so far as they are applicable, give more definite results, and are more immediately satisfactory, than those derived from comparison of observations in which no definite experimental variations have been made; but so far as regards causes of disease, or the action of supposed methods of prevention, or of remedies, it is unfortunately the case that we cannot draw accurate conclusions as to what will happen in man from what is observed to happen in animals. In the first place, there are many forms of disease in man, and those among the most important, as regards the suffering and loss of productive power and of life which they produce, which cannot, with our present knowledge, be experimentally produced in animals, and which rarely or never occur in them.

For example: Yellow fever is a disease which, from analogy, we have reason to believe may be due to the action of one or more specific micro-organisms, or, perhaps, I should say, to the products of such organisms. We find a dozen different kinds of bacteria in persons suffering from yellow fever, and, by dint of much labor, these have been isolated and cultivated outside the human body. The problem is to determine positively, and with scientific precision, which, if any, of these is the true, essential cause of the disease. The mode of doing this is by producing the disease in a perfectly healthy person or animal by the inoculation of the suspected organism. But, thus far, we have failed to find any animal in which a disease, which can be considered as specifically identical with yellow fever, can be produced by any method; and I need hardly tell you that inoculations of such a disease as this in a human subject, under conditions which would make the results of such inoculation scientifically trustworthy, are impracticable and unjustifiable.

Those forms of disease which are common to animals and man, such, for instance, as anthrax, tuberculosis, tetanus, hydrophobia, the ordinary forms of suppuration, and, perhaps, also typhoid fever, are being pretty thoroughly worked out by means of such experimental inoculations as I have just referred to; and we are able to say, with a great degree of precision, not only that these diseases are due to specific forms of bacteria, but to determine enough of the characteristics of these forms to be able to identify them wherever they are found.

For the great majority of diseases, however, this experimental method of determining the causes, and therefore, necessarily, experimental methods of prevention and treatment, cannot be employed in such a way as to distinctly isolate the effect of the particular agent or circumstance which we are investigating, and we must therefore resort to the other mode of advance of knowledge which has been referred to, namely, that of observing the phenomena as they occur in man, and endeavoring to so group the results of these observations as to determine the influence of a particular condition or set of conditions while all other circumstances remain uniform.

This method of observation may, for our purposes, be again divided into two categories. The first is that which is used in individual cases, being the form applied by the physician to each case which he has to treat. It also includes the sort of investigation which may be made in a single household, a small community, or a thinly populated district, to determine the course and cause of a particular form of endemic or epidemic disease, where the conditions affecting each family or dwelling can be studied in detail somewhat as the detective of modern fiction follows his clews. By the combination and comparison of detailed studies of this kind the greater part of our present system of diagnosis, prognosis, and therapeutics have been evolved; but it has been and will be a slow process, for each man differs from every other man in structure and mode of function, and the conditions of the environment are so multiform, and so variable in space and time, that "experience is doubtful, and judgment difficult." We must therefore try to supplement the information thus obtained by that derived from the second kind of observation above referred to, namely, that of collecting a few data with regard to great numbers of people, especially where these are accumulated in thickly settled localities, forming what is called the statistical method as applied to different communities. By the first method we compare individual with individual, and do so with considerable minuteness of subdivision of the conditions studied; by the second method we compare the vital phenomena of communities with those of other communities, but only on broad lines and in relation to circumstances easily noted.

The object of vital statistics is to classify and arrange the facts relating to the quantity and character of human life under different circumstances, for the purpose of determining the effect upon it of each of these circumstances taken singly, or of two or more of them acting together. The results thus obtained form an important part of the scientific foundations of sociology, of political economy, and of preventive medicine. It deals with masses of men and not with individuals, and its conclusions are, for the most part, applicable only to large bodies of people; yet its data are derived from individual records, and its results are accepted in many cases as a sufficient guide for individual action. They do not, in this respect, differ essentially from most of the motives which actuate us in daily life. The farmer sows his seed, the manufacturer builds his mills, the physician writes his prescriptions, and you come to hear this lecture from motives of probability; not carefully formulated in most cases, or capable of expression by a formula, but, nevertheless, in accordance with the doctrine of chances as determined by previous experience.

The term "vital statistics," in the sense in which I use it in these lectures, corresponds almost precisely to the French term "démographie" or the German "demologie," being applied to the circumstances of human life only, in the sense of Korosi's definition that it is the science of the physical life of human society. We will first consider briefly the sources of information and the character of the original data available for this study; second, the methods of arranging and using these data; and, third, the value and applicability of some of the conclusions which may be drawn from them, especially in that branch known as medical statistics.

The essential data of vital statistics are derived from enumerations of the living population and from records of births, marriages, and deaths.*

The numbering of the people is effected by a census, a term derived from the Roman Censors, a part of whose duty was to make such counts. Such enumerations

*Table Showing the Data Collected in the Censuses of Different Countries.**

A. ESSENTIAL REQUIREMENTS RECOMMENDED BY THE INTERNATIONAL STATISTICAL CONGRESS OF ST. PETERSBURG.

	Finland.	Sweden.	Norway.	Denmark.	Germany.		Prussia.	Bavaria.	Saxony.	Würtemburg.	Baden.	Hesse.	Oldenburg.	Mecklenburg.	England and Scotland.	Ireland.	Netherlands.	Belgium.	France.		Spain.	Italy.	Switzerland.	Austria.		Hungary.		Servia.	United States.
	December 31, 1865.	December 31, 1870.	December 31, 1875.	February 1, 1880.	December 1, 1875.	December 1, 1880.	December 1, 1875.	December 1, 1875.	December 1, 1875.	December 1, 1875.	December 1, 1875.	December 1, 1875.	December 1, 1875.	December 1, 1875.	April 2, 1871.	April 2, 1871.	December 1, 1869.	December 31, 1866.	April and May, 1866.	December, 1876.	December 31, 1877.	December 31, 1871.	December 1, 1870.	December 31, 1869.	December 31, 1880.	December 31, 1869.	December 31, 1880.	December, 1874.	June, 1, 1870.
a. Name	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
b. Sex	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
c. Age	1	A	A	1	A	J	J	J	J	A	A	A	A	A	1	1	J	J	A	A	1	1	J	A	A	1	J	1	1
d. Relation to head of family	..	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	..	1	1	1	1	1	1	1	1	1	..
e. Civil condition	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
f. Occupation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
g. Religion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	..	1	1	..	1	..	1	1	1	1	1	1	1	1	..
h. Language	1	1	1	..	..	..	..	..	L mat.	..	..	..	..	..	..	1	..	1	..	..	1	..	1	..	1	..	1	..	.
i. Can read or write.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..	1	..	..	1	1	1	1	1
j. Legal residence	..	1	..	..	1	1	1	1	1	1	1	1	1	1	..	..	..	..	1	1	1	..	1	1	1	1	1	..	.
Place of birth	..	1	1	1	..	1	..	1	1	..	..	..	..	1	1	1	1	1	1	1	..	1	..	1	1	1	1	1	1
k. Present residence	..	..	1	1	1	1	1	1	1	1	1	1	1	1	..	1	1	..	..	..	1	1	1	1	1	1	1	..	..
Residence during absence	..	..	1	1	1	..	1	1	1	1	1	1	1	1	..	1	1	1	..	..	1	1	1	1	1	1	1	..	..
Ordinary residence	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	1	1	..	..	..	..	..	..	..
l. Blind	..	1	1	1	..	..	..	..	1	..	..	..	1	..	1	1	1	..	1	1	1	1	1	1	1	1	1	..	1
Deaf-mute	..	1	1	1	..	..	..	..	1	..	..	..	1	..	1	1	1	..	1	1	1	1	1	1	1	1	1	..	1
Idiot or Cretin	..	1	1	1	..	..	..	..	1	..	..	..	..	..	1	1	..	..	1	1	1	1	..	..	1	1	1	..	1
Insane	..	1	1	1	..	..	..	..	1	..	..	..	..	..	1	1	..	..	1	1	1		1	..	1	1	1	..	1

B. OTHER REQUIREMENTS RECOMMENDED BY THE INTERNATIONAL STATISTICAL CONGRESS.

	Finland.	Sweden.	Norway.	Denmark.	Germany.		Prussia.	Bavaria.	Saxony.	Würtemburg.	Baden.	Hesse.	Oldenburg.	Mecklenburg.	England and Scotland.	Ireland.	Netherlands.	Belgium.	France.		Spain.	Italy.	Switzerland.	Austria.		Hungary.		Servia.	United States.
Auxiliary occupation	..	..	..	..	1	..	1	1	1	1	1	1	1	1	1	1	..	..	..	..	..	..	..	..	1	..	..	..	1
Grave diseases	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	..	..	..	..	..	..	..	..	1	..	..
Pupil in Primary school	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..
Kinship of wife	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Foundling	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

* Korosi, Joseph: Projet d'un recensement du monde étude de Statistique Internationale, Paris, 1881, pp. 42, 43.

were made by Moses (1490 B.C.), David (1017 B.C.); in Greece, 650 B.C.; and in Rome, beginning 566 B.C. They were probably made also in Assyria, but the Accad records have not yet been found. In modern times the first country to make a count was Sweden, in 1749. The first census in the United States was taken in 1790, as a necessary means of carrying out the constitutional provision that the basis of representation for the several States should be the number of the population in each. The first census in England was taken in 1801, and showed the number of persons, with distinction of sex, the number of houses, the number of families, and a rough statement of occupations under the general classification of agriculture, trade, manufactures or handicraft, and all others.

The first satisfactory English census, giving distinction of age, sex, occupation and birthplace, the number of persons blind and deaf and dumb, was the census of 1851. This was the first census whose data could be used in connection with the general system of registration of births and deaths.

The first attempts to take a census in a country have usually excited more or less suspicion and opposition, from fear that the information obtained would be in some way used to oppress the people. For example, several attempts to take a census have been made in Hayti but have always given rise to insurrection, and have always been defeated, owing to the belief of the people that it would in some way lead to their losing their liberty.

In the first censuses the object was to determine the number liable for military service or qualified to vote, or to fix rates of taxation, and the records were very brief. In the first United States Census the only data called for on the schedules were, names of heads of families, free white males over sixteen, free white males under sixteen, free white females, all other free persons, slaves.

The record of age was first made in the English Census in 1821, was omitted in 1831, and resumed in 1841. As the census records came to be more and more relied upon as a basis for legislation, additional details were introduced, and the above table shows those now included in the censuses of some of the principal countries of the world.

The relative importance of each of these details in studies of vital statistics varies greatly according to the purpose to which they are to be applied; but to physicians, sanitarians, and those interested in life insurance, the dominating factors are age, sex, and race. The power of reproduction, the tendency to death, and the liability to certain forms of disease, vary greatly at different ages in the two sexes, and this gives rise to corresponding variations in the disease- and death-rates of populations of different localities, or of the same locality at different times, when these populations differ as to the relative proportion of young and old, or of male and female, which they contain. These variations we must ascertain if possible, and estimate the influence of, in order to make reliable and useful studies of the effects upon human life of climate, altitude, race, occupation, or other conditions of the environment. In the course of these lectures I shall often have occasion to refer to this dominating influence of age, and to point out errors due to neglect of this factor, which is by no means an easy one to determine for many places, at many times. Even the census data require corrections, since people do not give their ages accurately to the enumerators. The tendency is to answer in round numbers as, 20, 30, 40, etc., and to a less but still marked extent, as 25, 35, 45, etc.; but the effect of this can be done away with to a considerable extent by properly grouping the individual data, as I shall explain presently. Ages over 90 are largely overstated, and the ages of women between 25 and 50 are largely understated; but these errors, being comparatively constant, and influencing the data of all communities, do not lead to erroneous conclusions of importance in comparing different communities, if the distinction of sex be observed.

One of the most interesting fields of study in vital statistics is the relation of race and color to birth-rate, to certain forms of disease, or to the liability of death at certain ages.

This country is, as you know, the great mixing ground for different races of the human family, and, while the mixture is rapidly becoming so intricate as to make it impossible to distinguish the several strains, it is still true that there are in this country large groups of men of quite distinct races, the record of disease and death in which would form valuable material for study upon this point were it possible to collect them.

From the sociological and political point of view this is particularly the case with regard to the negro and to those having a mixture of negro blood; and in the Southern States such questions as the following are of great practical interest. Is the negro population increasing faster than the white? Is the proportion of mixed bloods, such as mulattoes, quadroons, etc., increasing in proportion to the general population? Are the fertility and expectation of life of mixed bloods greater or less than those of pure whites or pure blacks under the same circumstances of environment? We will return to these questions hereafter; at present I merely refer to them as being the probable reason for the introduction into the law for taking the next census of a special clause providing "that the population schedule shall include an inquiry as to the number of negroes, mulattoes, quadroons, and octoroons," an attempt to obtain information which has not heretofore been sought in this way. In obtaining the records of deaths occurring during the census year beginning June 1, 1889, an effort will be made to have the deaths of colored persons distinguished into those of pure negroes and those of mixed blood. It will probably be impossible to obtain the data for either living population or deaths with the minuteness of subdivision indicated by the words "mulatto," "quadroon," and "octoroon"; but there is reason to hope that in many sections of the country we shall be able to distinguish those of mixed blood from the pure blacks and the pure whites, and to give some opinion with regard to their diseases and death-rates. The results of the last census, although imperfect, show such marked differences as regards the mortality from certain diseases, not only between the whites and the blacks, but between those of English, Irish, and German descent, as to make it certain that it will be worth while to pursue this branch of inquiry more minutely as opportunity is offered to us hereafter. The following table, taken from the last census, indicates the difference in the proportion of deaths from certain causes to the deaths from all causes in the white and colored population in the South and in those of Irish and German parentage in the North.

Deaths from—	White.	Colored.	Irish Parentage.	German Parentage.
Abortion	0.9	1.4	0.5	0.8
Accidents and injuries	43.8	67.6	61.0	52.5
Alcoholism	2.5	0.7	6.7	2.7
Cancer	19.1	7.8	24.3	25.8
Childbirth	13.9	24.8	14.1	18.3
Consumption	126.2	139.1	198.4	123.6
Croup	26.1	21.8	15.1	23.2
Diphtheria	39.8	17.4	42.1	72.7
Diseases of the bones and joints	3.1	2.0	3.1	2.5
Diseases of the digestive system	46.8	49.6	43.8	47.1
Diseases of the nervous system	119.1	96.9	94.7	109 4
Enteric fever	33.9	31.7	17.4	29.6
Heart disease and dropsy	56.1	64.5	62.3	60.9
Hooping-cough	14.3	33.0	6.0	8.4
Infanticide	0.05	0.14	.....	0.02
Malarial fever	30.7	48.3	12.9	14.1
Measles	9.1	17.7	5.3	8.5
Peritonitis	4.9	2.1	6.8	6.4
Pleurisy	2.7	3.7	2.9	2.6
Pneumonia	82.5	105.5	89.1	82.1
Puerperal septicæmia	12.6	10.2	12.5	15.7
Scarlet fever	20.9	3.9	24.0	30.1
Scrofula and tabes	6.2	16.0	2.7	2.6
Still-born	36.4	39 6	24.7	34.9
Suicide	3.2	0.5	2.7	7.2
Tetanus and trismus nascentium	3.1	9.3	1.6	2.2
Venereal diseases	1.7	3.0	1.4	1.3

The influence of race upon mortality is especially manifest in the death-rates of cancer. The number of deaths from cancer per 100,000 population in certain portions of the United States, with distinction of white and colored, was as follows: White, 27.96; colored, 12.67.

In the northern part of the United States the proportion of deaths from cancer in proportion to 1,000 deaths from known causes, with distinction of white, colored, Irish, and German parentage, was as follows: White, 19.1; colored, 7.8; Irish parentage, 24.3; German parentage, 25.8.

It will be seen from these that the liability to death from cancer is not half as great among the colored people as it is among the whites, and that there is a greater tendency to death from cancer in persons of German parentage than in all the average white population, especially between the ages of fifteen and sixty-five.

The relation of race to vital phenomena in general, and to disease- and death-rates in particular, forms one of the most interesting branches of what Galton calls the "science of heredity," but it is a branch in which little progress has yet been made, and for the study of which the United States offers greater opportunities than any other country. "The question of race influence is not merely an abstract matter fitted only for well-rounded periods in the discussions of the schools, but it profoundly affects vital and national life." It is a force which acts incessantly upon and menaces us, and, so far as we can now see, it is mainly upon the outcome of the distribution and prevalence of race that depend civilization, religion, and the future of man upon this earth. "In so far as the conditions of things tend to preserve the best types, progress is favored. In so far as they tend to destroy or to debase them with inferior types, progress is hindered. Not every mixture of race prevails, or persists, but there has been a certain amount of mixture wherever there has been progress in human affairs. Such mixture appears to have been a consequence rather than a cause, yet it may become an important secondary cause in changing or modifying the course of human events."

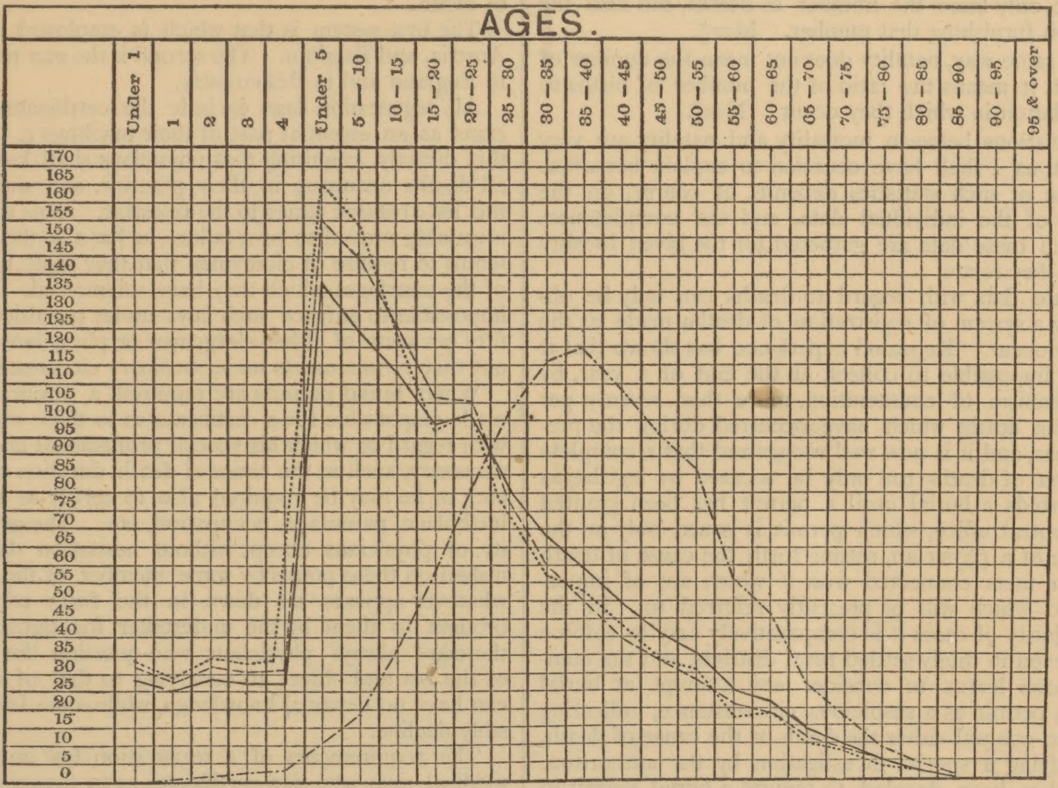
The census gives us a view of the population on a certain day, and, if well taken and properly compiled, it gives a general view of the stream of life as it flows on that day, with its variations of breadth and depth, from which it is possible to calculate, within certain limits, the velocity of the current, the rapidity of change, and the probable rate of increase or decrease, especially if comparisons can be made with the results of a previous census taken in the same way. It may also indicate periods of wide-spread disaster or of migration. For example, look at the diagram on opposite page, showing the proportions of the living population in 1880.

It shows that the decrease in the number living at each quinquennial group of ages was tolerably regular for the whole population for the native-born whites and for the colored as we proceed from the lower to the higher ages, as it should be under ordinary circumstances; but that there is one marked exception for the age-group 15 to 20, in which the line makes a sudden angle indicating a relative deficiency in the number of persons living at this age.

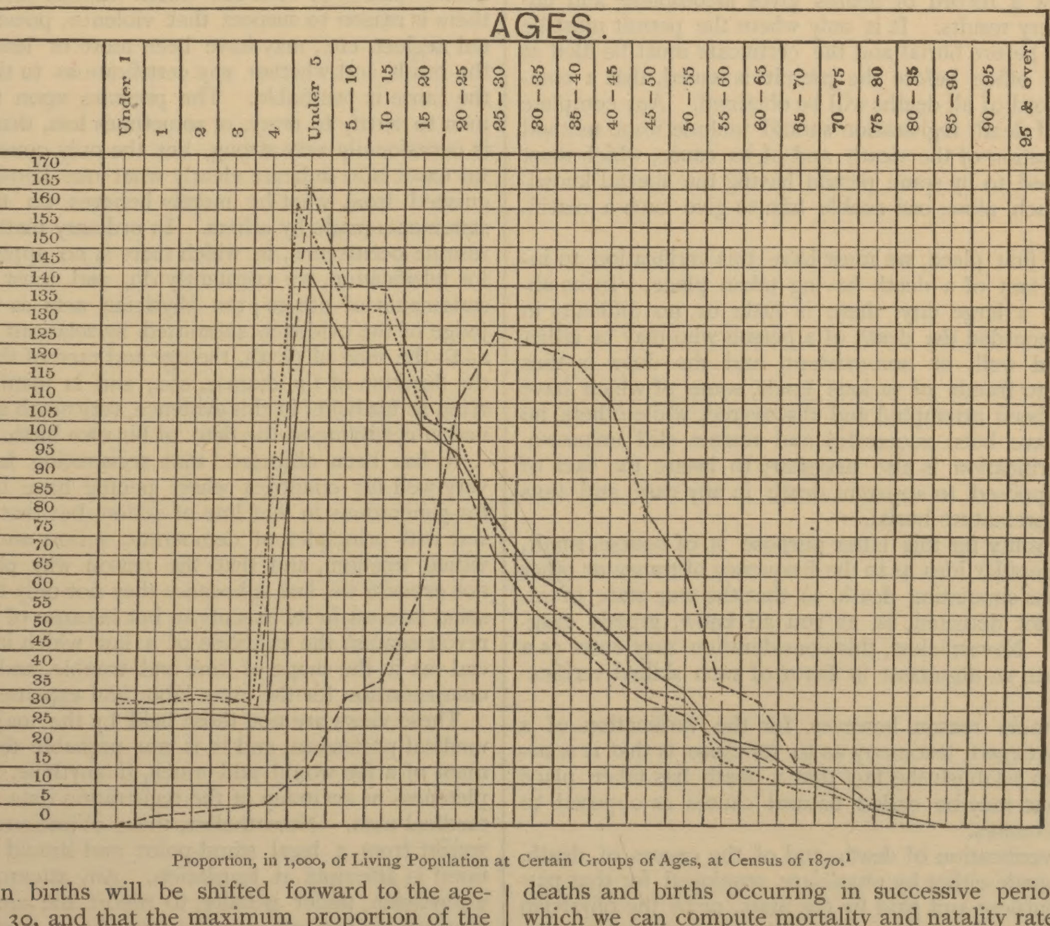
It will be observed, also, that the age-group in which there is the largest proportion of the foreign-born population is that from 35 to 40.

Now, if we compare this diagram with a corresponding diagram for the census of 1870, we find that this peculiar deficiency in the age-group, and the maximum proportion of the foreign-born, occur in those age-groups which precede by ten years the groups in which they occurred in 1880. The break or step in the descending line is in the age-group 5 to 10, instead of that of 15 to 20, and the maximum proportion of the foreign-born is in the age-group 25 to 30, instead of that of 35 to 40. Now, if we go back between five and ten years from the census of 1870, to see what special cause existed in that period for a diminution in the number of births, we find ourselves in the period of our civil war. These breaks or angles, then, are the scars of one of the wounds which the war inflicted, or, rather, they are like the spots and ridges on the finger-nails due to serious illness or local injury, which gradually grow out and disappear. The shifting of the maximum point in the line of the foreign-born population indicates

the unusually great immigration of Irish and German families containing young children, which occurred between 1850 and 1860, forming a wave whose crest is still perceptible. It is safe to predict that in a similar diagram for the census of 1890 the break or step showing deficiency in births will be shifted forward to the age-group 25 to 30, and that the maximum proportion of the foreign-born will be in the group 45 to 50.



Proportion, in 1,000, of Living Population at Certain Groups of Ages, at Census of 1880.[1]



Proportion, in 1,000, of Living Population at Certain Groups of Ages, at Census of 1870.[1]

[1] ——— All classes; — — — — native white; -·—·—·—·— foreign-born white; ...... colored.

In general, we may say that the census indicates the state of the population at a given period. Vital statistics, however, consider both the state and the movement of the population, and therefore for these we must have something more than the census, viz., a record of the deaths and births occurring in successive periods, from which we can compute mortality and natality rates.

Mortality, or mortality rate, refers to a ratio between the number of deaths occurring and the number of living population furnishing those deaths. It is to be distin-

guished from a statement of the number of deaths, since to determine the mortality in a given population we must not only know the number of deaths, but also the population furnishing that number. $M=\frac{D}{P}$.

In the same way, natality does not mean the number of births, but it means the ratio of the number of births to the population in which they occur. $N=\frac{B}{P}$.

The relations between mortality and natality are very important, as I shall have occasion to explain hereafter. The value of such statistics depends, of course, on the accuracy of the individual data, and the completeness with which these data are gathered for the given locality to which they relate.

Accurate data with regard to deaths can only be obtained by a system of registration of deaths made at the time they occur. Repeated experience has shown that it is utterly impossible to collect, at the end of a year, by any mechanism of enumeration, more than seventy per cent. of the deaths which have occurred during the preceding year, and it is now well recognized that a complete registration of deaths can only be secured by legislation which forbids a burial until a permit has been granted from a central office, which permit is issued only on the certificate of a physician, setting forth the cause of death and other facts connected with it which are of importance, and which will be presently referred to. In the great majority of cases it is comparatively easy to enforce the law, even in thinly settled rural districts, and the community soon learns to consider any attempt at burial without a permit as a suspicious circumstance, indicating a desire to conceal either the death or the cause of death, and justifying a special investigation by the authorities. When it has been decided to require a burial permit in all cases, it is not usually difficult to require the data for registration as an indispensable preliminary to the issuing of such permit.

Any system which depends upon the returns of undertakers for a record of deaths gives incomplete and unsatisfactory results. It is only where the permit must be obtained before burial and the certificate must be filed at a central office before the permit is issued, that a complete record of all deaths will be obtained. Any complete system of death registration should include some method of verification of the death and of its cause, which must be certified to by some person having the special knowledge which alone can enable him to give such a certificate.

In the first place, we must have this verification to insure the fact of a death having taken place. In its absence, in a large city, there is little or no difficulty in having recorded the death of a person who may be either alive and well, or non-existent, and the door is thus opened to frauds of various kinds, some of which have actually been attempted and discovered, while others, no doubt, have been successful and remain still unknown. Such verification is also necessary to insure the fact of real as opposed to apparent death in any case, and thus prevent premature burial.

The utility for this latter purpose is, of course, small, for the popular idea as to the frequency of trance or other conditions simulating death, so that the true state of affairs is not detected, is, as you all know, grossly exaggerated. Nevertheless, this consideration may enter as a factor into an argument in favor of such skilled verification.

The main reason, however, for the verification of a death by expert testimony as to its cause, is that it is necessary to establish the fact that a death has taken place from what may be called natural causes as opposed to criminal causes.

This verification of death, and of the causes of death, may be made either by physicians employed for that particular purpose and paid by the State, or by the physician under whose charge the deceased person has been immediately previous to death; in which latter case only those cases which have not been under the treatment of a physician are referred to a public medical officer, or the coroner, for verification and determination of the cause of death.

The first system is that which is employed in France, Austria, and Belgium. The second is the one made use of in England and in this country.

All registration laws include the certificates of physicians as an essential part of their machinery. Some do this directly, requiring that physicians shall keep a list of all deaths occurring in their practice, and shall forward this list at stated times to the registrar. This method has invariably proved to be a failure, as has also the similar attempt to require of clergymen that they shall furnish lists of the marriages which they have solemnized. It is utterly impossible to enforce such laws under penalties, and not fifty per cent. of either clergymen or physicians will carry out their requirements under ordinary circumstances.

Where burial permits are required, a physician may be made responsible for a certificate as to those matters only with regard to which his special professional knowledge is necessary, such as the cause of death, duration of sickness, etc.; or he may be required also to certify as to the age, birthplace, parentage, occupation, etc. The great majority of physicians accept without hesitation the data furnished on these points by some member of the family, or whatever appears set down in the form of certificate brought to them by the undertaker for signature. But there are always physicians who question the propriety of the law and object to certifying to that of which they can have no personal knowledge, while some few may possibly decline.

The requirements of a registration law impose upon medical men who sign certificates as to causes of death a very considerable responsibility, much more considerable, in fact, than many of them probably realize. The physician is to consider whether his knowledge of the case is sufficient to enable him to determine whether or not the death was due to what are called natural causes, whether there is reason to suspect that violence, poisoning, criminal neglect, etc., may have been more or less factors in the result, and whether any certificate as to the nature of the cause is justifiable. The pressure upon the medical man to certify to more, or sometimes less, than he knows, is occasionally very strong, but the only course in doubtful cases is to indicate clearly what one knows, as distinguished from what he merely believes on the faith of statements made by others. In ordinary matters of daily routine occurrence, in which there is no apparent motive for falsification, we constantly do, and must, accept the statements of others; the physician acts as the primary judge of the evidence submitted by relations and friends as to the time of death, the age and race of the decedent, the duration of the disease, etc., and is justified in certifying to his belief in this evidence, very much as he is justified in certifying to the date of his own birth.

It has been objected [1] that registration laws may do very well for countries where people have been trained for generations in that line of action, but that they are at war with principles of democratic action and with individual freedom, and that the reason why physicians do not execute the law is because they not only have no personal interest in its execution, but because of a feeling of revolt against the injustice of a law which inflicts a special tax in the shape of time and trouble, and affords no compensation for the extra labor and expense.

These views are not those held by the majority of the medical profession, and it is not probable that the payment of a fee would add much, if anything, to the completeness or accuracy of the registration data furnished by medical men. Nevertheless, these objections have some weight from a legal stand-point, and should be borne in mind in attempts at legislation. Any attempt to compel a physician, under penalty, to report the age and birthplace of his patients, would certainly be worse than use-

[1] Dr. H. M. Lyman, in the Chicago Medical Journal, 1878, p. 252.

less. The policy is not to call upon medical men to submit the information which should be demanded from the parent or householder. Under the police power of a State, certificates of the cause of death may be required from physicians as being necessary to secure life and protect property, but returns for merely statistical purposes, such as of births, cannot be required of any other than the parent.

There is no good reason why reports of births should be required from medical men. But as regards reports of deaths, it is to the interest of properly qualified members of the medical profession that such certificates should be demanded from them. Whenever and wherever certificates as to the cause of death are required from physicians, there must also be established some system of determining who are physicians within the intent of the law.

At first it may be necessary to accept certificates from anyone and everyone who chooses to call him or herself a physician; but the character of some of the documents of this kind, which will come in, will very soon indicate the necessity for some discrimination. Thus it is that the certification of the causes of death by physicians is the essential foundation, and it is the only essential foundation, of legislation with regard to the qualifications which the State has a right to demand from practitioners of medicine.

The registration of marriages, births, and deaths is important to the individual, because it gives him increased security in his rights to property and to life, by enabling him to furnish proof of parentage and legitimacy, by increasing the chance of detection of fraudulent claimants to property of which he is the true heir, and by discouraging criminal attempts to shorten his life, owing to the fact that evidence must be furnished that death was due to natural causes, or a special legal investigation of the circumstances will be made. Of the importance to the community as a means of protection of health and life, and to scientific men and physicians as a means of investigation of some of their problems, I need give no proof to this audience.

We can hardly be said to have a complete system of registration of births in any State or city in this country. Probably the city of Providence, R. I., has the most complete records of this kind of any of our cities. As regards the registration of deaths, Massachusetts, New Hampshire, Vermont, New Jersey, the greater part of Connecticut and New York, a large part of Alabama and Minnesota, and most of our large cities, have now a fairly satisfactory system and complete record. For the rest of the United States, there is either no system of registration, or, if any exists, it is a very imperfect and incomplete one, the results of which cannot be depended upon, and which cannot be compared with the results obtained in the localities above referred to as having a complete system; and the only means which we have of estimating the mortality of these localities is by the reports of deaths for the preceding year collected by the census enumerators.

It is for this reason that the decennial United States Census is a matter of such great importance to scientific medicine, and to practical sanitation—of much greater importance, in fact, than most physicians and health officials seem to fully appreciate. It is true that the death-records thus obtained in the large areas of the country in which there is no registration are incomplete, and, as regards causes of death especially, inaccurate; but they are the best we have; they are becoming better at each census, and the death-records in the registration areas serve to measure their reliability, and to indicate to some extent useful corrections.

As the value of statistics of deaths depends very largely upon the possibility of comparing them with corresponding statistics of the living population furnishing those deaths, it is evident that the modes and times of obtaining and of publishing the results of the census are matters of great importance to medical and sanitary statisticians. This is especially true as to the frequency with which a census is taken, the units of area made use of in its published tables, and the combinations of age, sex, race, and occupation data given in connection with such units of area.

Let us first consider briefly the time of taking the census.

The conclusions of the various statistical congresses with regard to the methods of the census are summed up by Korosi in his project for a census of the world, published in 1881.

The first of these conclusions was that the census should be taken every ten years, in the month of December, and in those years the number of which terminates in zero; recommending, however, that intermediary censuses should be taken at the discretion of different governments.

The taking of the census at the end of December has the advantage that a relatively greater number of population are in their own homes then than at any other time, and that it corresponds to the termination of the calendar year, at which date many State and municipal reports terminate, so that all the figures, being for one date, are readily comparable with each other. For a very large part of this country it would be quite as easy to take the census at the end of December as on the first of June; but there are some sections in which attempts to take the census in the midst of cold and rainy weather, for a thinly scattered population, would be made under very great difficulties.

In a paper read at the British Health Congress in May, 1889, Sir Edwin Chadwick urges the desirability of an annual census for the improvement of public administration, referring to the fact that, "in commerce and in manufactures, as in every large company, there is an annual stock-taking, and upon that stock-taking a report and declaration of the results is made to the stockholders. But what is the state of the political administration which has only attained to a stock-taking of the living people, of the healthy and the weakly, on whom the power and the prosperity of the county depend, which is only attempted every ten years, and is only completed in three years, leaving the numbers, meanwhile, to be got at by estimates, necessarily erroneous—often widely erroneous? An annual census of the more numerous animal stock has been lately striven for and attained, and is worked out by the Agricultural Department of the Board of Trade. It is some forty-five millions of the agricultural stock, while the population of England and Wales is about twenty-eight millions. Other nations, as France and the United States, have halved the inconvenience of the stock-taking of the human population."

Sir Edwin is in error in this last statement, for the United States Census is taken but once in ten years, and but a few States have thus far taken the intermediate census, which would make the enumeration come at quinquennial periods.

In the law providing for the last census, an attempt was made to induce the States to take this intermediate census by an offer that the United States should pay one-half of the amount paid to all supervisors and actual enumerators in the State, increased by one-half of the percentage of gain in population in the State, provided that the schedule used should be similar to those used in the census of the United States, and that a full copy of all schedules returned, and reports made, should be deposited with the Secretary of the Interior on or before the September following.

This provision, however, has not had the effect designed, probably for the reasons set forth in the report on the census of Michigan for 1884, namely, that at least two months are required to make the enumeration, transmit the blanks to the Secretary of State and arrange them, which leaves but one month (August) for correction of errors and for making the full copy of the schedules. As applied to the State of Michigan, this would require a thousand or twelve hundred clerks for twenty-five days. The amounts paid the supervisors and enumerators for the United States Census of 1880 were $71,192.06, one-

half of which, increased by one-half percentage of gain gives $42,401.99 as the amount Michigan would have received from the General Government if its census had been taken in conformity with the national census law. But it would have cost from sixty to seventy thousand dollars to copy the schedules and reports, or from eighteen to twenty thousand more than the amount that would have been received from the national treasury to compensate for the work. A few sets of territorial schedules were sent in, but nothing was done with them.

Sir Edwin, however, urges that even the quinquennial census would be considered insufficient for business purposes in the ordinary affairs of civil life, and refers to the fact that the proposition for an annual census in the European governments was discussed at the International Statistical Congress at the Hague, having been proposed by himself and strongly seconded by Professor Engle, the head of the Statistical Bureau of Prussia. The matter was appointed to be the subject of discussion at a future Congress, but in the meantime the meetings of the Congress were interrupted, and the matter has never again come up as a subject for international discussion.

Annual censuses have been tried and abandoned in Canada. Triennial censuses have also been tried, but the general conclusion seems to be in favor of five-year periods.

In Austria, Belgium, the greater part of the British Empire, Denmark, Holland, Hungary, Italy, Norway, Sweden, Switzerland, and the United States, the census is decennial.

In the Sandwich Islands a census has been taken every six years since 1853.

In France a census was taken in 1801, 1806, and every five years since 1821.

In Sweden every five years from 1775–1860.

In Germany every five years since 1866.

In Finland every five years since 1875.

In Sweden every three years from 1749–75.

In Baden every three years from 1818–67.

In Hanover every three years from 1830–64.

In Prussia every three years from 1834–67.

In Saxony every three years from 1834–67.

In Bavaria every three years from 1834–67.

In Upper Canada (now the Province of Ontario) a census was taken annually for nineteen years from 1824–42.

In New Zealand nine censuses have been taken since that of 1851, at intervals of from three to seven years, the last interval being five years.

In Queensland there is also a quinquennial census.

While it is not probable that any agreement for an annual census of the whole country will be made in the near future, either by the United States or by State governments, it is certainly quite possible that the desirability for more frequent enumerations in the larger towns and cities will soon become so evident as to lead to systematic arrangements for carrying it out. Even now, many cities take what they call a police census, at irregular intervals of from three to five years, for the purpose, mainly, of making rough subdivisions of the voting populations in the form of precincts, and of obtaining information for the purpose of levying taxes, more especially for school purposes. These police censuses, however, relate only to adult males, and upon them are based estimates of the number of the remaining population, which are used by the sanitary officials in computing death-rates. These estimates, however, are almost invariably too high, as is shown by the next State or National census, and, in any case, afford no satisfactory basis for computation as to the number of inhabitants in the different wards of the city, owing to the great variations in the ratio between the voting population and the rest of the people in different classes of society and in different parts of a town.

By the use of proper schedules, somewhat on the English system, left at each house, there should be very little extra expense over that of the ordinary police census in collecting sufficient data with relation to the entire population of a city, to give accurate data with regard to the vital statistics of the population, and these, combined with a good system of registration of deaths and marriages, would give the means for a system of vital statistics of a place such as, at present, no city in England or in this country possesses.

The unit of area made use of in furnishing the census data is a very important matter in connection with the statistics of deaths, for, practically, these last must be classified by the same areas. The census units of area have usually been fixed by political considerations with reference to votes, to taxation of various kinds, and to military service. In this country the smaller unit is usually the county or city, or, in some cases, the wards of a city, the larger units being the State or Territory.

For the purposes of vital and medical statistics such units of area are often of little or no importance, because the boundaries of wards, of cities, of counties, and of States are not fixed with reference to the peculiarities to topography, drainage, character of habitations or of the people, which are important factors in the causation of disease and death, and which, therefore, require study, as much so as with reference to dividing the population for purposes of representative government. Moreover, in the publications of the several censuses prior to that of 1880, the population of the smaller areas, such as cities and counties, was, as a rule, given with distinction of sex and of color only, while the most important factor in vital and medical statistics, namely, age, was stated in detail for States only. In the census of 1880 an important advance was made in this respect, for, in connection with the mortality statistics, the population of each county having ten thousand inhabitants and upward, and of the large cities, was given with distinction of age under one year and under five years, for each sex of each color.

In the next census the population by counties will be given with still further distinctions of race; it will be given with distinction of age under one year and under five years for wards, and in about two dozen of the largest cities it is proposed to select certain areas which present peculiarities as to topographical features, or as to the character of the people inhabiting them, and to give the population of these by age, sex, and color, as a basis for the study of the death-rates of these localities. In a large city like New York, even the ward is usually too large to be a satisfactory unit of area for statistical study, since one ward will contain some of the best and some of the worst habitations, and include classes of people having very different means, habits, and death-rates.

In the annual report of the city of Brussels the population, births, and deaths, are given by streets, courts, and alleys. This does very well for Brussels, where the streets are short; but in our large cities, regularly laid out in rectangles, where the streets are miles in length, and traverse localities differing widely in topography and in character of population, it does not seem to be applicable.

The data required on individual certificates of death should correspond to those required on the schedules of living population, and, in addition, should give the cause of death.

The death-rate, or mortality, is the ratio between quantity of life and loss of life. It refers to a definite unit of time, viz., one year's life of one person, and the quantity of life is the sum of the time lived by each of the population expressed in years. Two persons living six months each, or twelve persons living one month each have one year of life. If the population is assumed to be stationary, that is, one in which the births and deaths, and the emigration and immigration, are exactly equal to each other and similarly distributed throughout the year, then the number of the population multiplied into the time under consideration, expressed in years and fractions of years, gives the quantity of life

A population usually, however, increases in geometrical

progression, and in such case we must find, by means of a well-known formula, the mean population of the period, which will be less than the arithmetical mean of the populations at the beginning and end of the period and greater than the population living in the middle of the period; but the differences are small, and, in most cases, either figure may be employed.

For example, suppose we wish to calculate the death-rate of New York City for the year 1888. By the censuses of 1870 and 1880 we know the population on June 1st in each of those years. From these we determine the ratio of increase, and thence the population on January 1 and December 31, 1888, from which the mean population can be computed, or the arithmetical mean be taken. Or, we can compute directly the population on July 1, 1888, and it makes little difference as to probable accuracy which of these three estimates of population we take.

You will perceive that this method rests on the assumption that the ratio of increase of a locality during ten years as determined by the census continues unchanged and uniform thereafter. This is hardly ever true, and, for many localities in the United States, and especially in the rapidly growing West, it is very far from the truth, which is a strong argument for more frequent counts.

Various methods are used by statisticians to correct the estimates of population made for a city at periods other than during a census year, as determined by a formula of arithmetical or geometrical proportion, among which may be mentioned the use of the ratios supposed to exist between the number of houses or the number of voters, or the number of school-children and the total population. The number of houses is determined from tax records or by a special count; the number of voters by registration lists or by a police census; the number of school-children by a special census; and the ratio which these bear to the whole population is guessed at or is calculated from the data obtained at the last census.

The most useful and reliable of these methods is the use of the average numbers of presumed occupants of inhabited houses, the other ratios being of very little value.

This has been very well shown by Dr. Russell, Medical Officer of Health at Glasgow, in a paper on "The Decennial Census as a Basis for Statistics in Intervening Years," Glasgow, 1881. In the case of Glasgow he considers the estimate of her population based on the number of inhabited houses and the estimate based on preceding censuses, and finds that both methods give a population above the actually existing one as shown by the next census. The error in the estimates based on the previous census was due to a change in rate of growth. The error in that based on the number of houses was due partly to incorrect data of the number of inhabited houses, and partly to an error in calculation.

In the United States Census of 1870 the number of persons in a dwelling in the large cities varied from 14.07 in New York to 5.20 in Toledo, these differences being due, to a considerable extent, to the counting of large tenement-houses containing numerous families as a single dwelling.

If we take the data by families, we find in the same census that the largest number of persons to a family was in Kansas City, the number being 5.78, while in New York it was but 5.07.

In 1880 the proportion of persons to a dwelling ranged from 16.37 in New York to 4.68 in Memphis. In Baltimore it was 6.54; in Boston, 8.26; in Philadelphia, 5.79. The number of persons to a family was: In Baltimore, 5.8; in Memphis, 4.23; in New York, 4.96; in Philadelphia, 5.13.

It is evident that no value can be placed on estimates of population of a city based upon the number of habitations it contains if a cottage and a tenement-house are to be equally reckoned as a habitation.

Estimates of the population based on police censuses, on the number of school-children, or on city directories, are of very little use, being, in almost every case, in excess of the truth. No general rules can be laid down for the estimation of the population of a city at a period between two censuses. It is a special problem in each case, for the solution of which there is needed an acquaintance with the locality, to be sure that boundaries have not changed, the information which can be obtained from special local censuses, from the number of inhabited buildings, from migration statistics, etc., all of which must be applied to the data furnished by the last general enumeration of the people, which, in any case, must be resorted to for the ratios which are to be used.

It is to be observed that municipal statisticians and registrars rarely make use of the means afforded by a general census to correct the figures of population, and, therefore, rarely alter death-rates which they have given for the years intervening since the last census; yet it is highly desirable that this should be done, in order to prevent the use of misleading figures. For example, in Chicago, in 1873, the registrar estimated the population of the city at 400,000, and deduced therefrom the death-rate for the year as 23.89. Comparing the populations in 1870 and in 1880, it was apparent that the true population was about 350,000, giving a death-rate of over 27.

In Boston, in 1876, the estimated population at the time was 352,758, giving a death-rate of 23.39, while the true population, as shown by comparison of census data, was about 313,000, giving a death-rate of over 26.

The shorter the period for which a death-rate is given, the greater is the liability to error. The ordinary forms of weekly death-rates reported for large cities are annual death-rates; that is, they represent what would be the annual death-rate if the proportion of deaths to the population for the week continued for one year. If, for example, a town having a population of 100,000 reports as its weekly death-rate for a given week 25 per 1,000, this does not mean that during the week there occurred 2,500 deaths, but it means that if the population and number of deaths each week are continued the same during the year, 2,500 deaths would have occurred in the course of the year, or that for the week in question the number of deaths was 2,500 divided by 52.17747. A weekly death-rate is useful to show where the greatest variations have been in the year's mortality, but it is no indication of the health of a town for a particular week, and it is useless as a means of comparison of the healthfulness of one town with that of another. This is largely due to the law of probable deviation or error in mortality statistics in relation to the number of instances used as data without reference to their accuracy. This law of probable error in relation to number of data is an exceedingly important one, to be kept in view in all statistical inquiries, and especially in those relating to vital and medical statistics.

For example, suppose that in a village of a thousand inhabitants there occur 25 deaths in the course of a year, and in a neighboring city of 10,000 inhabitants there were 200 deaths in the same time. What is the probability that the death-rate of 25 per 1,000 for the first, and 20 per 1,000 for the second, indicate the relative healthfulness of the two places, supposing the data to be perfectly accurate, and that we have no other information in regard to them than that stated?

Or, suppose that during one year, in a population of 100,000 persons, there occur 2,000 deaths, what is the probability that in a second group of 100,000 persons, under the same circumstances, the number of deaths in a year will not be less than 1,950, nor more than 2,050?

The answers to such questions as these are furnished by formulæ derived from the mathematical laws of probability. The simplest of all these formulæ, and the one most practically useful for rough and ready calculations in cases such as that given in the first example, is, that the mean or probable error is equal to the square root of the number of the dead. By this rule the probable error for the village of 1,000 inhabitants, for 25 deaths, would be 5, and therefore the mortality in this place might vary between 20 and 30 per thousand, without any certain indica-

tions of variation in the sanitary conditions of the place. In the city of 10,000 inhabitants, with 200 deaths, the probable error is a little less than 15, the variation between 185 and 215 corresponding to an average mortality of 18.5 to 21.5 per thousand, being a probable variation of only 3 per thousand instead of 10, as in the first case. It is very clear, then, that in comparing these two mortality-rates, no positive conclusion can be drawn as to the relative healthfulness of the two cities, seeing that the probable variations overlap, as it were, for the rates ranging from 20 to 21.5.

The formula that the probable variation in the number of deaths is the square root of that number, gives results that are somewhat too great, being merely an approximation to the true formula, which is of much more general application, but requiring too much computation for general use. I shall refer to this matter of the law of error in more detail in speaking of medical statistics. For the present, I only call your attention to the fact that it is necessary to bear in mind the absolute numbers as well as the percentages, and that, therefore, statements of ratios only are insufficient for definite conclusions.

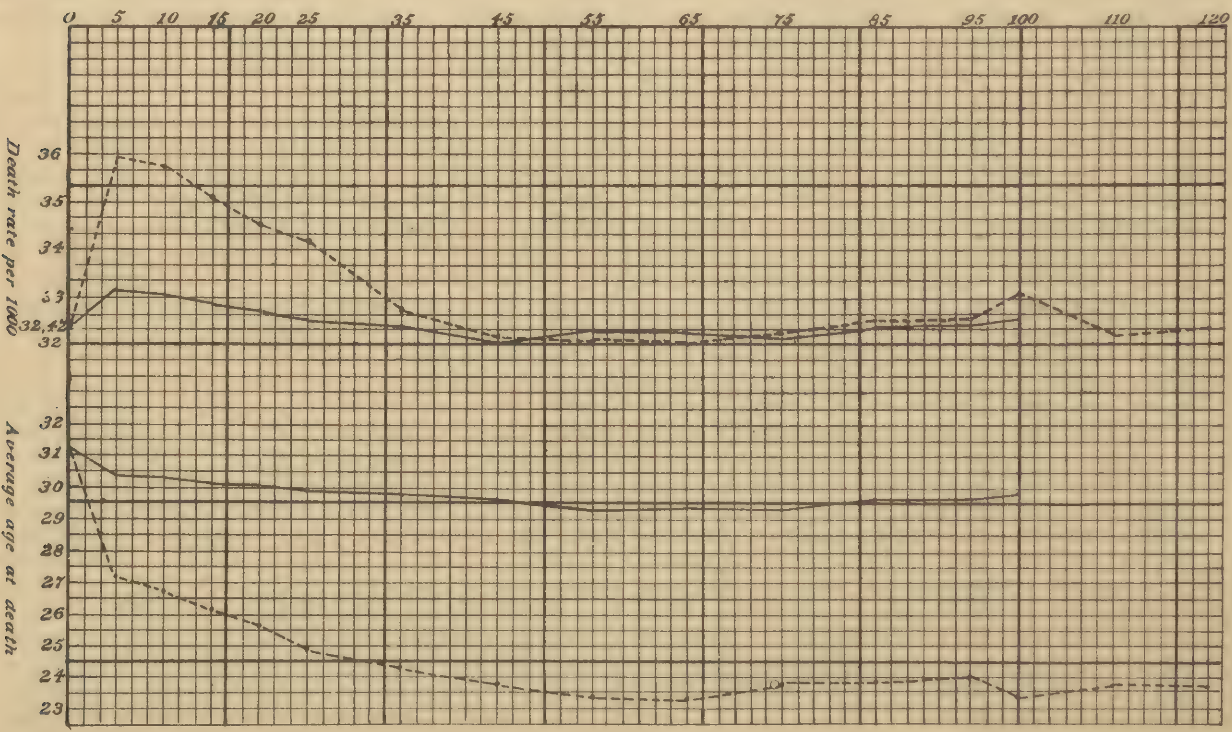
of an annual calculation of birth-rates and their comparison with the deaths of children under one year of age, or those born within the year. We can only obtain this data for any large extent of country by referring to the census records.

The usual method of indicating the birth-rate is by giving it as the proportion per 1,000 of births to the population of all ages; but a much better and more satisfactory mode of computation is to calculate the number of births to the number of women between the ages of 15 and 50 or 55 living in the community referred to.

The general subject of birth-rates is interesting chiefly in relation to social statistics, to the fecundity or rate of increase of population or of people of different races; but, in relation to mortality statistics, it may also become an important factor in the calculations.

There has been from time to time some controversy between statisticians and health-officers with regard to the influence of birth-rates upon death-rates, or as to the precise relations which exist between the two. As the death-rates of infants are much greater than those of the population at higher ages, it has been claimed by some that

Diagram Showing the Effect of an Increased Birth-rate Upon the Death-rate, and the Average Age at Death.[1]



What is a fair or normal death-rate? Taking an average healthy rural district in the United States, where there is little migration, the annual gross death-rate for the whole population will be from 13 to 15 per 1,000. In towns of from 10 to 15,000 inhabitants, having a good general water supply and proper sewerage, the gross death-rate should not exceed 16 per 1,000. In cities of from 20,000 to 100,000 inhabitants it should not exceed 17 per 1,000, while in cities of over 100,000 inhabitants it should not exceed 19 per 1,000. The great causes of high death-rates are poverty, overcrowding, intemperance, excess in heat and cold, with moisture, foul air, bad food, impure water, uncleanness, contagion, ignorance, etc.

Births and Birth-rates.—The statistics of births are of much importance in vital statistics, because of the influence of the birth-rate upon the sex- and age-distribution of the population. Unfortunately, in this country, as I have already explained, hardly any locality possesses such an enforced system of registration of births as to permit

where there is a high birth-rate there also is a high death-rate; but it cannot be said that this will invariably be the case, or that the one is directly the cause of the other, except in certain cases for a comparatively short series of years. This will be best understood from the above diagram which shows the course of events as regards birth-rates in a population in which the number living at each age, or group of ages, corresponds substantially with the distribution which existed in New York City in 1879, 1880, and 1881, when reduced to the life-table basis.

Starting with such a population as this, numbering in all 308,378, supposing that there are no migrations, and taking the death-rates for each group of ages to be shown by the New York life-table, we have calculated the progress of such a population for 100 successive years, under two suppositions—the first for a constant birth-rate of 35 per 1,000, and the second for a constant birth-rate of 45 per 1,000. The death-rate at the commencement was 32.42 per 1,000. Under the influence of a constant birth-rate of 35 per 1,000, this death-rate increases during the first period of five years to 33.17, and after that steadily sinks until, at the end of 55 years, it becomes less than the origi-

[1] - - - - - - - Fixed birth-rate of 45 per 1,000; ——— fixed birth-rate of 35 per 1,000.

nal death-rate, and at the period of 65 years has sunk below it; after which it again rises until, at the end of 100 years, it has reached the rate of 32.44.

Taking now the same population, under the same circumstances, at a constant birth-rate of 45 per 1,000, we see that the death-rate rises in the first five years to 36 after which it steadily sinks as it did in the former case, until, after the lapse of 60 years, it is only 32.01, after which it again rises and finally comes down to a point a little below that from which it started. In both these cases, then, it is evident that the high birth-rate for a time produces an increased death-rate, since there are no other circumstances present to account for the change. But after the first five years the proportion of those living at the ages at which there is the lowest mortality has been so much raised as to more than counterbalance the large number living in the first years of life, and, therefore, the death-rate steadily descends.

But, to understand the full effect of this change, it is also necessary to consider the average age at death, which is shown in the lower diagram. Here it will be seen that the average age at death being 31.37, decreases to 29.65 under the influence of a constant birth-rate of 35 per 1,000; while, with the higher birth-rate of 45 per 1,000, it diminishes as the death-rate diminishes to the age of 65, at which period it is only 23.02, after which it again rises as the death-rate increases.

If we compare the proportions of the population living at each group of ages at the beginning and end of the one hundred years under each of these two different birth-rates, it will be seen that, under the influence of the higher birth-rate the proportion of the population under twenty-five remains high, while after that age it falls below the original figures.

As a rule, high birth-rates occur in cities, and in the crowded parts of cities, among the laboring classes of the population, where the causes of disease and death in infants are especially prevalent.

On the other hand, it is to be noted that a high death-rate among infants has some tendency to increase the birth-rate, because the interval between child-bearing is shortened by the early death of the infant; and in the effort made by poor women to avoid frequent child-bearing, a common means is to suckle the infant up to at least two years of age, in order to prolong the interval between pregnancies—which is a practice injurious both to the mother and to the child.

If we had under consideration a community in which there were no migrations, and in which the population neither increased nor diminished, the relations between birth-rate and death-rate and the average duration of life could be expressed by a simple formula, in such a way that, given either two of these quantities, we could determine the third. If, for example, in a population of 1,000 persons, five births and five deaths occur annually, and if we assume that every individual lives to the same mean age, evidently just 200 years would elapse before the whole of the original 1,000 would have died. This 200 years would be the mean duration of life, and this would be the case also if deaths occurred at different ages, only in such a case many would die below the mean age; when some would greatly exceed it. This subject has been considered by Dr. J. S. Bristowe in a paper "On the Mutual Relations of the Birth-rate and Death-rate."[1] From the table which he gives I have extracted that part which shows the mean duration of life under certain conditions of birth-rate and death-rate, where the birth rate varies from 3 to 5, and the death-rate from 15 to 35, in a thousand.

Dr. Bristowe says: "There can be no difference in the healthiness of two localities in one of which the death-rate is twice as high as that of the other, provided other conditions are such that in both cases the inhabitants attain the same mean age; or, conversely, supposing different populations to enjoy the same mean duration of life, any differences which may be presented by their respective death-rates are due to other circumstances than differences of health." He also says that the average duration of life can be determined by the birth-rate and death-rate taken together, but not from the death-rate alone. If he means by healthiness mean duration of life, this statement is equivalent to saying that, where the mean duration of life is the same it will be alike—an indisputable proposition, though not a very instructive one. But if by healthiness is meant the sum of the conditions of the locality as to altitude, drainage, cleanliness, etc., which tend to lessen or increase deaths in the people living in it, then the statement is incorrect, for it does not take into account age, sex, or race distribution, occupations, or migrations. Setting the question of migrations entirely aside, it is perfectly possible that two populations, attaining the same mean age and having the same death-rate, may live in two localities, one of which is decidedly healthier than the other; so that, if the two communities exchanged habitations, a marked difference in the death-rates and mean age at death would result.

Putting aside all these purely speculative considerations with regard to what might happen in a stationary population where there is no migration, let us see what the significance of death-rates is in our cities and rural districts, as they now exist. We wish to know how much of the death-rate is due to peculiarities in the character and occupation of the population itself, and how much to peculiarities in the locality, and for each of these classes we wish to know how much is necessary and unavoidable, and how much is due to causes which may be modified or done away with. Precise knowledge on these points we can never have, but we can obtain a sufficient degree of probability to guide our action in the premises.

If we wish to study carefully the influence exerted upon health and life by race characteristics, by residence in a given locality, by marriage, occupation, social standing, etc., we must have the means of comparing results given in different localities, or in the same locality at different times, or for different races, occupations, etc., under like circumstances.

To accomplish this we must, as far as possible, estimate the influence of other circumstances not connected with the particular point which we are investigating, but which, notwithstanding, exercise a powerful influence upon sickness and death-rates; and of these, the two most important influences are those which differences in proportion of sexes and ages of the population to be compared exert.

The means recognized as best calculated to eliminate the influence of sex and age, by, as it were, reducing the population to one uniform scale in these respects, is by calculating the expectation of life at each age for all the several conditions of locality, occupation, etc., which we wish to investigate; in other words, by the preparation of what are known as life-tables. A life-table shows what would be the tendency, or liability, to death at each age in a population in which there is no migration, and in which the births and deaths just equal each other, if such a population were subjected to the same influences tending to produce diseases and death as have affected the actual population under consideration, and from which the data are derived. It is, of course, impossible to prepare life-tables which shall be strictly accurate and exactly comparable one with another, because it is impossible to obtain strictly accurate data. A life-table is intended to answer the question, "Of a million children born, how many of each sex die at each age?" or, "What is the time which a man or woman of a given age may be expected to live?" A strictly accurate answer to this question could be given only if we knew the precise dates of birth and death of each of a million of children, born under the circumstances we are investigating; and, strictly speaking, these million children should all be born on the

[1] St. Thomas's Hospital Reports, New Series, vol. vii., London, 1876, p. 245.

same day. Notwithstanding, by using large masses of data which are more or less attainable, and by applying certain well-known corrections, the individual errors tend to neutralize each other, and we can prepare tables which will be quite accurate enough for purposes of comparison.

A vast amount of labor has been expended upon, and study given to, this subject; for immense business interests and important points in the jurisprudence of inheritance depend upon the existence and accuracy of these tables. Hundreds of millions of dollars have been, and now are, invested in life insurance on the faith that certain life-tables truly represent the average course and duration of the life of a particular class of the community—and the result of more than a hundred years of experience has been applied to their correction under the powerful stimulus of urgent need, from a pecuniary point of view, to have them as accurate and reliable as possible.

Probably the earliest form of such a table known is that given in the Pandects of Justinian by Domitius Ulpianus, commonly known as Ulpian, a distinguished lawyer, who was the secretary of Alexander Severus, and who wrote in the beginning of the third century of the Christian era. This table is found in an extract from his writings given in the Pandects in a treatise by Æmilius Macer.

Ulpian states that in Rome registers of Roman citizens, including the data of age, sex, and death, were kept by the city from the time of Servius Tullius to that of Justinian, including a period of one thousand years. From these data, which applied to the more prosperous class, Ulpian gives a scale for estimating the purchase value of communities according to the different values of life at different ages, and sums it up in saying that it is usual to compute thirty years' maintenance for all those under thirty years of age, and that for all over that age as many years are allowed as they lack of sixty.

In connection with the question of annuities, Ulpian gives a scale for estimating them, which is apparently the probable length of life of persons of the ages named.

The following table, compiled by Mr. Hendricks (*Assurance Magazine*, vol. ii., 1852, p. 223), gives the relative value according to these authorities.[1]

Age completed.	Years' purchase according to		Expectation of life (mean of males and females).		Years' purchase according to Carlisle table for annuity on life.	
	Ulpian.	Macer.	Stockholm.	Carlisle.	4 per cent.	5 per cent.
Birth	30	30	16.17	38.72	14.28	12.08
5	30	30	34.08	51.25	19.59	16.59
10	30	30	33.00	48.82	19.58	16.67
15	30	30	30.08	45.00	18.95	16.23
20	28	30	26.93	41.46	18.36	15.82
25	25	30	24.10	37.86	17.64	15.30
30	22	30	21.70	34.34	16.85	14.72
35	20	25	19.60	31.00	16.04	14.13
40	19	20	17.43	27.61	15.07	13.39
41	18	19	17.03	26.97	14.88	13.24
42	17	18	16.64	26.34	14.69	13.10
43	16	17	16.25	25.71	14.50	12.96
44	15	16	15.86	25.09	14.31	12.80
45	14	15	15.47	24.46	14.10	12.65
46	13	14	15.08	23.82	13.89	12.48
47	12	13	14.70	23.17	13.66	12.30
48	11	12	14.31	22.50	13.42	12.11
49	10	11	13.92	21.81	13.15	11.89
50	9	10	13.53	21.11	12.87	11.66
55	7	5	11.59	17.58	11.30	10.35
60	5	(?)	9.57	14.34	9.66	8.94
65	5	(?)	7.80	11.79	8.31	7.76
70	5	(?)	5.98	9.18	6.71	6.33
75	5	(?)	4.24	7.01	5.24	4.99

The first life-table of modern times was constructed in 1692 by Dr. Halley, from the registers of the city of Breslau for five years, and was printed in the "Philosophical Transactions" in 1693. The data for this and for other similar tables constructed in the eighteenth century were too imperfect to permit of good results, and the first life-table which was selected as of sufficient accuracy for business purposes is what is known as the Carlisle life-table, compiled by Mr. Milne in the early part of the present century.

We now have a considerable number of life-tables applicable to the special classes of those who are likely to insure their lives, derived from the experience of a large number of insurance companies in Europe and in this country; and also a number of life-tables derived from the data of the whole miscellaneous population of the country for England, France, Germany, Sweden, and for certain parts of this country.

In order to prepare a life-table for a given locality or occupation, we must know the number of persons living at each year of age, and the number of deaths at each age which have occurred among these persons for one or more years.

We assume that deaths have occurred at regular intervals during the year for each age and proceed to compute the number of persons at each age, who were living in the middle of the period for which the deaths are registered.

In using census data, however, we cannot directly compare the deaths at each single year of age with the number reported by the census as living at that age, because of the strong tendency of the average man or woman to report ages either of the living or of the dead, but especially the former, in numbers which are multiples of ten or five, or in so-called round numbers. This will be seen from the following table, which is an extract from the census record of 1880, with regard to Massachusetts and New Jersey. The figures given are for whites only.

Ages.	Massachusetts.				New Jersey.			
	Population.		Deaths.		Population.		Deaths.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
19	17,425	18,661	118	157	10,717	11,025	60	70
20	17,481	21,555	144	159	10,611	12,482	63	65
21	16,422	17,744	132	156	10,384	9,856	59	84
24	15,858	18,934	129	174	9,460	10,165	87	94
25	17,502	20,201	130	160	9,755	10,668	77	69
26	14,652	16,816	111	166	8,506	9,037	53	73
29	11,813	13,102	116	127	6,981	7,293	77	71
30	20,583	21,967	133	162	11,425	12,411	71	80
31	9,493	9,946	101	106	5,776	5,561	45	60
39	8,798	10,153	111	131	5,929	5,985	68	47
40	20,146	20,748	148	169	12,500	12,165	105	99
41	6,624	7,277	84	82	4,189	3,924	59	46

An examination of these figures will show that the death-rates calculated from them would indicate that the mortality at 25, 30, and 40 is much less than at the ages immediately preceding and following them. Thus from the above figures it would appear that in Massachusetts the mortality of white males at the age of 50 is only 9.42 per 1,000, while at the age of 49 it is 16.11, and at the age of 51 it is 19.16 per 1,000. There is, however, no such abrupt change in the law of mortality at the age of 50 as these figures would indicate, and it is necessary, therefore, to make corrections for this source of error.

It is true that the error in the number of deaths reported at the even decades is usually in the same direction as the error in the number of the living population, and therefore tends to neutralize the error in the computation of ratios; but this is not always the case, as will be seen in examining in the above table the deaths reported in New Jersey for females at the ages 24–26; and as the ages of the dead are usually reported more accurately than those of the living, the error would be almost invariably in the direction of making the mortality at the even decades too low, and for the adjacent years too high.

The error in question may be corrected in distributing the excess reported at the even decades to the adjacent years, by aid of the calculus; but the easier and usual

[1] From Introduction to Justinian's Digest, pp. 190–192. Henry John Roby: Cambridge University Press, 1884.

way is to calculate the mortality rates by groups of ages, including five or ten years in each group—that is, for the periods 20–24, 25–30, 30–34, etc., or for the periods 20–29, 30–39, etc., or for the periods 25–34, 35–44, etc. Of the three modes of grouping, the last is the best, because it properly distributes the excess about the even decades, which is the greatest.

If we take the group of ages 20–29, 30–39, etc., the whole excess for the year 30 is distributed in the succeeding years, whereas a part of it really belongs to the years in the preceding group. This objection applies to a much less degree to the grouping of 35–44, 45–54, etc., for the excess at 45 is much less than at either 30 or 40; still, it is well to remember that approximate life tables, calculated as I shall indicate, give for this reason somewhat less than the true mortality, and somewhat too high an expectation of life for adult ages.

This source of error affects all mortality statistics derived from the results of a national census, and from the ordinary system of registration, but it does not affect mortality statistics derived from the records of life insurance companies, in which it may be presumed that the ages of both the living and decedents are accurately stated.

I do not propose to describe the methods of constructing a life-table. To make one sufficiently accurate to be used for the purposes of life insurance requires elaborate calculations and corrections, and the use of complicated mathematical formulæ; but the construction of an approximate life-table, in which no attempt is made to secure regular gradation, is a comparatively easy matter, and has been fully described by Mr. N. H. Humphreys in a paper in the "Journal of the Statistical Society" for 1883, which method was made use of in calculating the approximate tables given in the mortality statistics of the last census.

A few words of explanation, however, are necessary with regard to the headings of columns in the specimen life-table which is before you. The column headed Mx is the mortality or death-rate of each group of ages as shown in the left-hand column, which is obtained by dividing the number of deaths by the mean population of that age. It signifies the mortality at any age, or group of ages, x.

The column headed Px indicates the probability of living a year at any given age, x.

The column headed Lx shows the number surviving at each year of age out of a given number taken as a starting point. For example, during the census year, in New York City the births of males and females were in such proportion to each other that out of a million children born, 516,385 would have been males and 483,615 would have been females. Starting, then, with this number 516,385 males as living at birth, the age first in the column lx, we find that in the next year, by the action of the death-rate shown in the column Mx, this number has been reduced to 380,689.

The column headed Qx shows the number of years which the persons who survive at that period of age will live after that age, that is to say, the total quantity of life remaining at any given age, x. From this is readily deduced the expectation of life; that is to say, the average mean after-lifetime of each individual.

LIFE TABLES.—APPROXIMATE LIFE TABLES FOR CERTAIN STATES AND CITIES.[1]

Life Table for Providence, Boston, and Massachusetts, for Years 1883–1887, Inclusive, and for Following Ages.

		0	5	10	15	30	50	70
Mx..	Providence	0.1748	0.0089	0.0039	0.0069	0.0111	0.0225	0.0898
	Boston	0.2505	0.0098	0.0043	0.0076	0.0132	0.0212	0.0686
	Massachusetts	0.2190	0.00724	0.00383	0.00654	0.01000	0.0149	0.0519
Px..	Providence	0.8394	0.9611	0.9961	0.9931	0.9889	0.9777	0.9140
	Boston	0.7776	0.9903	0.9956	0.9925	0.9869	0.9790	0.9337
	Massachusetts	0.8026	0.9927	0.9962	0.9935	0.9901	0.9852	0.9494
Lx..	Providence	1,000,000	720,990	689,360	675,920	593,880	465,100	251,900
	Boston	1,000,000	625,085	593,310	582,608	494,517	357,317	169,755
	Massachusetts	1,000,000	702,037	676,745	663,751	584,836	461,070	263,310
Qx..	Providence	40,814,885	36,843,580	33,317,705	29,904,505	20,349,305	9,744,005	2,446,755
	Boston	33,273,508	29,661,144	26,620,157	23,675,362	15,623,017	7,078,692	1,716,680
	Massachusetts	40,836,745	37,003,338	33,571,710	30,220,470	20,876,424	10,393,055	2,985,142

New York City (Data for Three Years Ending June 30, 1881).

Ages.	POPULATION, JUNE 1, 1880. White and Colored. Male.	Female.	ESTIMATED POPULATION, JULY 1, 1880. White and Colored. Male.	Female.	DEATHS FOR 1879–1880, 1881. White and Colored. Male.	Female.
0	15,738	15,385	15,770	15,417	14,313	11,673
1	12,054	11,712	12,079	11,736	4,815	4,388
2	14,796	14,686	14,826	14,716	2,414	2,261
3	13,975	14,199	14,004	14,228	1,605	1,541
4	14,029	13,753	14,058	13,781	1,152	1,002
5–9	63,096	63,385	63,226	63,516	2,221	2,098
10–14	56,462	57,087	56,578	57,205	710	701
15–19	52,759	62,144	52,868	62,272	1,015	1,080
20–24	59,294	71,049	59,416	71,195	1,932	2,004
25–34	107,360	110,951	107,581	111,180	4,708	4,500
35–44	87,865	82,872	88,046	83,043	5,293	4,176
45–54	54,767	54,635	54,880	54,748	4,553	3,415
55–64	26,096	27,349	26,150	27,405	3,518	2,888
65–74	9,322	11,840	9,341	11,864	2,524	2,533
75–84	2,639	4,045	2,644	4,053	1,283	1,732
85 and over	262	693	263	694	253	602
Total	590,514	615,785	591,730	617,053	52,309	46,594

Ages.	Mx (= MORTALITY AT AGE x). White and Colored. Male.	Female.	Px (PROBABILITY OF LIVING ONE YEAR AT AGE x). White and Colored. Male.	Female.
0	0.30253	0.25239	0.73722	0.77589
1	0.13288	0.12463	0.87540	0.88268
2	0.05427	0.05121	0.94716	0.95007
3	0.03820	0.03610	0.96252	0.96454
4	0.02732	0.02424	0.97305	0.97605
5–9	0.01171	0.01101	0.98836	0.98905
10–14	0.00418	0.00408	0.99583	0.99593
15–19	0.00640	0.00578	0.99362	0.99424
20–24	0.01084	0.00938	0.98922	0.99066
25–34	0.01459	0.01349	0.98552	0.98660
35–44	0.02004	0.01676	0.98016	0.98338
45–54	0.02765	0.0207[illegible]	0.97273	0.97942
55–64	0.04484	0.03513	0.95614	0.96548
65–74	0.09007	0.07117	0.91381	0.93128
75–84	0.16172	0.14243	0.85038	0.86704
85 and over	0.32122	0.28897	0.72323	0.74751

[1] These tables are taken from my work on the Mortality and Vital Statistics of the United States, Tenth Census, 1880, Part II., 1886, p. 785.

LIFE TABLES.—*Continued.*

Ages.	Lx (Number Surviving at Age x). White and Colored. Male.	Lx (Number Surviving at Age x). White and Colored. Female.	Qx (Total Number of Years of Life Remaining to Survivors at Age x). White and Colored. Male.	Qx (Total Number of Years of Life Remaining to Survivors at Age x). White and Colored. Female.
0	516,385	483,615	14,997,256	15,847,959
1	380,689	375,232	14,548,719	15,418,535
2	333,255	331,211	14,191,747	15,065,313
3	315,647	314,673	13,867,296	14,742,371
4	303,815	303,514	13,557,565	14,433,277
5	295,627	296,245	13,257,844	14,133,397
10	278,814	280,377	11,821,742	12,691,842
15	273,048	274,715	10,442,087	11,304,112
20	264,448	266,890	9,098,347	9,950,100
25	250,497	254,662	7,810,985	8,646,220
35	216,490	222,524	5,476,050	6,260,290
45	177,174	188,186	3,507,730	4,206,740
55	134,373	152,860	1,949,995	2,501,510
65	85,811	107,575	849,075	1,199,335
75	34,842	52,783	245,810	397,545
85	6,890	12,673	37,150	70,265
95	270	690	1,350	3,450

Expectation of Life.

Ages.	White and Colored. Male.	White and Colored. Female.	White and Colored. Persons.*	Ages.	White and Colored. Male.	White and Colored. Female.	White and Colored. Persons.*
0	29.04	32.77	30.90	35	25.29	28.13	26.71
1	38.22	41.09	39.66	40*	22.54	25.24	23.89
2	42.59	45.49	44.04	45	19.80	22.35	21.08
3	43.93	46.85	45.39	50*	17.16	19.36	18.26
4	44.62	47.55	46.08	55	14.51	16.36	15.44
5	44.85	47.71	46.28	60*	12.20	13.76	12.98
10	42.40	45.27	43.84	65	9.89	11.15	10.52
15	38.24	41.15	39.70	70*	8.47	9.34	8.90
20	34.41	37.28	35.84	75	7.05	7.53	7.29
25	31.18	33.95	32.56	80*	6.22	6.54	6.38
30*	28.24	31.04	29.64	85	5.39	5.54	5.46

* Interpolated arithmetical means.

Such records as these are the cardiograms and sphygmograms of the life of a nation or of a community. They are hard to get, and not easy to read in many cases, but nothing can take their place as a means of judging of the effects which circumstances are producing on the fertility, health, and vitality of the people.

ON VITAL AND MEDICAL STATISTICS.

Lecture II.

The term "expectation of life" is used by different writers in different senses, and hence has often given rise to confusion and misunderstanding. It should be used only in the sense of the mean after-lifetime, that is, the average number of years which persons at any given age, in a given place, may expect to live. In a stationary population, where there is no migration, and where the births are exactly equal in number to the deaths, the expectation of life at any age would be found by dividing the sum of the number of years which the whole population lived after that age by the number actually living at that age.

Table showing Expectation of Life.

		Ages.						
		0	5	10	15	25	40	60
American Life Insurance Companies.	Males ..	....	....	49.9	46.6	39.5	28.5	14.5
Massachusetts, 1883–87	Males ..	39.7	52.7	49.3	45.1	38.2	28.2	15.3
Boston, 1883–87	Persons.	33.3	47.2	47.5	44.7	37.1	28.5	16.7
Providence, 1883–87	Persons.	40.8	51.1	48.3	44.2	37.5	27.7	15.0
New York, 1879–81	Males ..	33.3	48.0	44.9	40.6	33.2	23.9	13.0
Baltimore, 1880, colored	Males ..	21.0	41.8	40.0	36.8	31.0	21 7	11.3
Society of Friends, Philadelphia	Persons.	43.7	51.8	48.8	44.6	37.5	28.5	15.6
Society of Friends, England	Males ..	45.3	53.8	50.5	46.4	39.9	29.2	14.4
Benedictine Monks, Paris	....	....	....	....	....	34.6	24.0	11.7
English Life Insurance	....	....	50.6	45.6	40.6	34.0	24.5	12.6
Dublin, 1841	Males ..	23.8	38.5	37.2	33.4	27.0	19.8	11.0
Berlin	Males ..	17.2	44.9	43.1	39.5	32.0	22.0	10.0

The term "expectation of life" is often confused with the "probable duration of life," which is the age at which a certain number of new-born children will be reduced one-half; so that for any one of these children it is an equal chance as to whether it will die before or after that age. The difference between the probable duration of life and the expectation of life may be understood from the following example: Suppose that of 100 children born, 30 live one year, 20 live five years, 30 live forty years, and 20 live sixty years. Then the probable duration of life is five years, because at the end of five years just one-half of these children will be dead, so that at the beginning it is an even chance for any one child as to whether it will die before or after the age of five years; but the expectation of life of any one of these children is 25.3 years, because these 100 children will in all live 25,300 years of life. In like manner, if ten of these children were to die at the end of every five years, the probable duration of life would be 25 years, and the expectation of life would be 27.5.

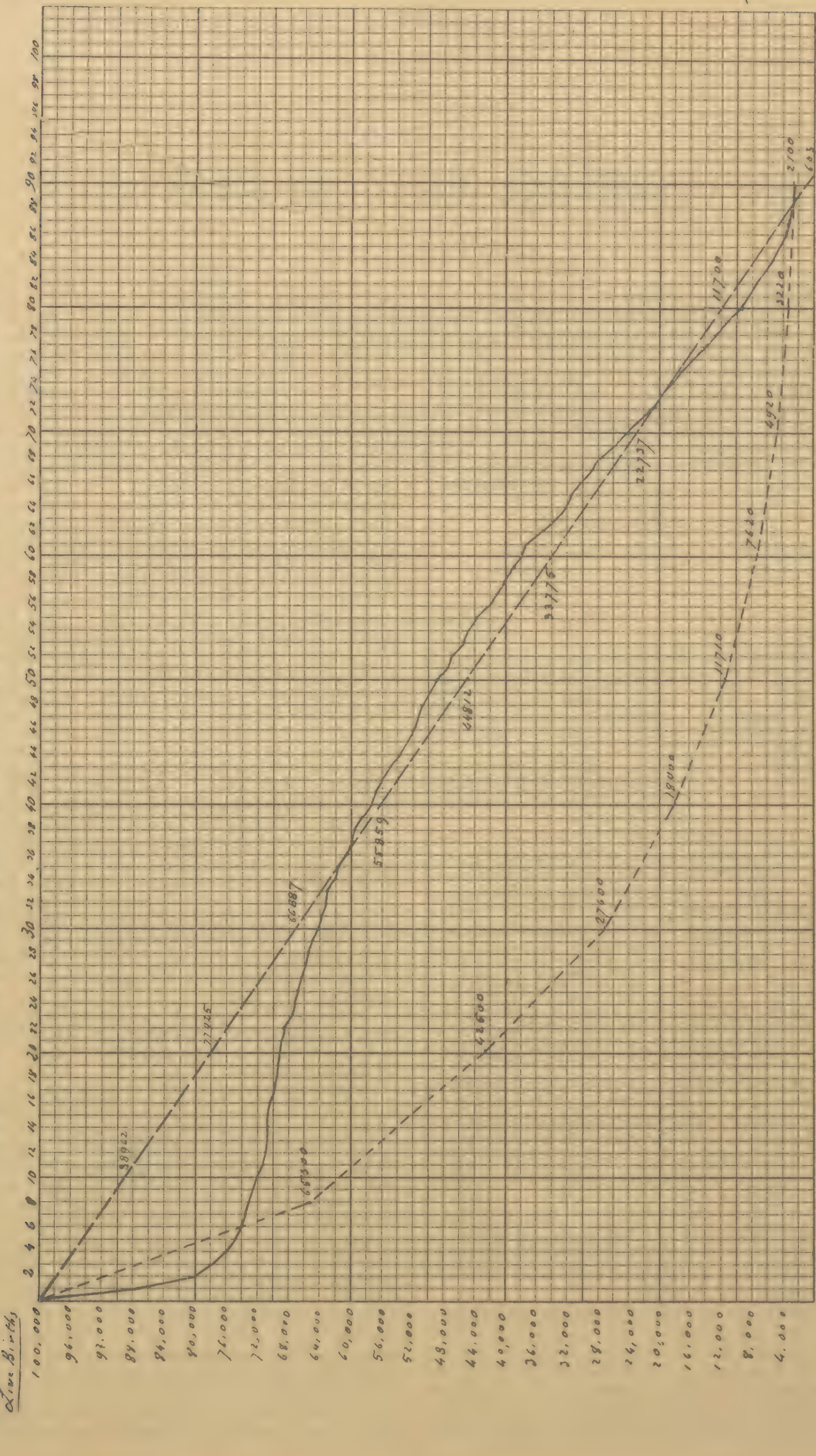
Another phrase sometimes used in vital statistics is "specific intensity of life." This is the quotient of the dividend of the number of persons living at any age by the number dying at that age, that is, $\frac{Px}{Dx}$, being the reverse of the ordinary mortality ratio.

The chief source of error in an approximate life-table constructed directly from the census figures and a registration of deaths, without correction or adjustment, is due to the fact that there is a very considerable error in the number given of the living population in the first six or seven years of life. Usually the census figures show that the number of children two years old is greater than the number one year old, and that the number four years old is greater than the number two years old, owing to a tendency to erroneously report a child at these ages as being older than it is. If we undertake to adjust or correct these figures so as to truly represent the number living at each year, we usually have to make some assumptions as to the law governing the mortality, or as to what is sometimes called the law of life. This expression, the law of life, refers to the hypothesis that variations in mortality at successive ages take place in a regular succession which may be geometrically represented by a curve, and that therefore, if we know the mortality at certain ages in a given community, we can, if we know this curve, and if the number of observations were sufficient, deduce the mortality at other ages. Numerous formulas have been proposed for this purpose, from that of De Moivre in 1727, which is $Y = 86 - x$, x being the age, and Y the corresponding number of the living, to the latest and most generally accepted formula of Gompertz, as modified by Mr. Makeham. This last is based on the assumption that a person's power of resisting death decreases as his years increase, so that at the end of infinitely small periods of time he loses infinitely small portions of his remaining power to resist destruction, death being considered as the consequence of two generally existing causes, the one a progressive, necessary deterioration, the other chance. If, for instance, there were a number of diseases to which young and old were equally liable and which were equally destructive at any age, the number of deaths among the young and the old by such diseases would evidently be in the proportion of the number of the young to that of the old. If there were no other causes of death but these diseases, the number of living and dying would decrease in a geometrical progression as the age increases. But if the liability to death is constantly increasing in a given ratio as the man grows older, then the number of the living will decrease in a greater ratio than a geometrical progression would indicate.

The diagram before you shows the diminution of vital force with advancing age as shown by De Moivre's hypothesis, by the geometrical progression formula, and by the English life-table.

This line of human life, which in some respects is not unlike the line in the palm of the human hand which the ancient teachers of chiroscopy also called the line of life, is that of the healthy and normal individual. Many persons do not at any time possess the amount of vital force which it represents; many infants at birth have but the capacity for a few hours or a few days of existence. Some men begin to grow old at forty; the atheromatous degeneration invades their arteries, the heart becomes fatty, and at fifty they are in extreme old age as regards the processes of retrograde metamorphosis, and the ability to resist death. Calculations and corrections based on such formulæ as these give interesting results, and are useful to life-insurance work, but they are unnecessary to the purposes of the sanitary statistician. Even the fundamental hypothesis upon which Gompertz' law is based, that the proportion of deaths at a given age is constant, is always untrue for any given age, as the prevalence of infectious and contagious diseases of various kinds, and

Diagram showing, out of 100,000 *Children Born alive, the Number that Survive to each of the Undermentioned Ages.*[1]



[1] See A. Newsholme, The Elements of Vital Statistics, p. 237. London, 1889. —— Dr. Ogle's line (English life table), 1871–80; — — — Dr. Moivre's line, May 1, 1886; - - - - Geometrical progression line.

of various lethality, varies with different years, and for this reason it is desirable to have the records of deaths for a considerable period of time—at least three years, and, better, ten to twenty years, in order to correct these variations.

It is impossible to calculate a life-table for the United States as a whole, since we have no accurate information as to the total number of deaths occurring in any given period of time in the United States, and still less as to the number of deaths occurring at each group of ages. But even if such table could be prepared, it would be of very little interest or use, since the conditions of the various sections of the country as to climate, occupations, prevailing diseases, character of inhabitants, etc., are so widely diverse that the average or mean would scarcely be applicable anywhere. The most useful life-tables for sanitary purposes are those which relate to certain circumscribed localities, such as a single city, or even a single ward of a city; but for scientific and medical purposes, the most useful are those which relate to particular classes of people, particular occupations, etc. There is a special difficulty in preparing an accurate life-table for a city, due to the effect of migration into and out of the city, from and to the surrounding country, which disturbs very much the rates of death at different ages. The mortality in a great city is almost always reported as less than that which the actually existing causes of death and disease tend to produce, because domestic servants, shop-girls, and others, who have come from the country, go back to their rural homes when their health begins to fail after a year or two of city life, and there die. This is especially the case in regard to deaths from consumption and diseases of that class. The groups of ages which are thus specially affected are those between fifteen and twenty-five years, and therefore the mortality at this group of ages in the large cities, as calculated from the number of deaths, is too small to properly represent the causes of death acting on the population at those ages. On the other hand, the mortality at the same ages in the rural districts near the city will be correspondingly unduly increased.

The data necessary for the construction of life-tables are comparatively rarely available for the purposes of the sanitarian. Hence, while admitting that these furnish the only true measure of public health, registrars of vital statistics and sanitarians have sought for other standards for such measurement, the data for which could be more readily obtained and more easily applied. Especially has the search been made for some means of measuring sanitary conditions and progress from the data furnished by deaths alone without reference to population. One of the most common of these is the use of the period of infancy from 0 to 5 years, by comparing the number of deaths at this period with the total number of deaths. It is very certain that the period of infancy gives the most sensitive test of sanitary conditions, but the comparison must be made, not with the total number of deaths at all ages, but with the number of the living population furnishing such deaths.

In Europe it is more common to confine the calculation to children under one year of age, and these are much more valuable there than they would be in this country because they have there a much more complete registration of births, and therefore the relation between the number of infants born and dying within the first year of life can be ascertained with an exactness which is quite out of the question in this country.

Another method, which we can only use for a census year, is the use of the ratio which exists between the total number of births during the year and the number dying during the year out of this number of births. This is not the same as taking the total number of those dying under one year of age. For example, in the city of Brooklyn, during the last census year, there were 8,805 births, and of these 1,408 died—leaving, on the date of the census, 7,397 living children under one year of age, putting aside the effects of migration; but the total number of deaths of white male children under one year of age in Brooklyn was 2,059—hence 159.9 per 1,000 of those born within the year died within the year, while the deaths of children under one year were 278.4 per 1,000 living at the end of the year, with a still higher rate for the year.

The test of sanitary condition which is most generally employed in this country is the proportion of the number of deaths which occur in children under five years of age to the whole number of deaths reported. This does fairly well in comparing the rates of the same city, in which it may be presumed that the general ratio of age-distribution is nearly uniform at different times, but it is a very fallacious method of comparing rates of different cities or localities. For example, during the last census year the ratio of deaths under five years per 1,000 of total deaths was in Alabama 475.9 for males—in California, 250.0; but in Alabama the proportion of male children under five years to the total population is 17.5 per cent., while in California it is only 9.1, or but little over half the Alabama ratio, and hence the true rate is actually higher in California than it is in Alabama, although the figures would indicate the reverse.

Much the same may be said of comparison of deaths at a given age-group to total number of deaths, which is apt to give very misleading conclusions. For example, suppose, in a given city, the total number of deaths of children under five years of age were thirty per cent. of the total deaths, while in a given class of people in the same city they were only ten per cent. of the total deaths; it would be by no means safe to infer that this special class was in a better sanitary condition, because among the poorer classes the proportion of children is always relatively large, which implies a large population exposed to these special diseases, and consequently a larger number of deaths under five years of age, without reference to the sanitary condition.

Another test which has been proposed is that of the mean age at death, which is the quotient of the sum of the ages of different individuals at death, divided by the total number of deaths. This is only useful in comparing the conditions of two populations when the age and sex constitutions of these populations is the same. It is out of the question to apply the test to different occupations; as, for example, to compare the mean age at death of major-generals with that of second lieutenants. The chief use of this test is in its application to different causes of death, but even for this purpose the death-rate in relation to population is much better.

A considerable part of the errors to which one is liable in comparing the mean age of different occupations at death may be avoided by excluding from the computation all deaths of children under five years of age.

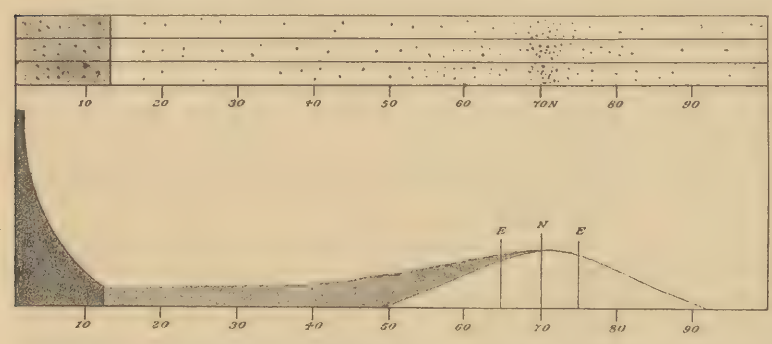
Although the expectation of life, or mean after-lifetime, is the standard of comparison almost universally accepted by statisticians, it is, in some respects, not a very satisfactory one, since it is often misunderstood by the public, which is apt to use the word "mean" in the sense of usual or ordinary, that which occurs most frequently. But the ordinary lifetime, or, as Bertillon calls it, the *vie normale*,[1] is a very different matter, as will be seen from the diagram on next page.

This indicates that after the perils of childhood are passed the greatest number of deaths cluster about the age-period of seventy years, and the popular phrase here would be that it was a premature death which occurred in a man under sixty years of age.

The great majority of the mortality statistics prior to the present century are necessarily incorrect and unreliable, because they are based, for the most part, on the data of deaths alone. The deaths can only be taken as a measure of probable duration of life for any community when the births and deaths are equal and there is no migration, a state of matters which must very rarely happen and be of very brief existence.

[1] Bertillon, M. Jacques: Sur la Vie moyenne et la Vie normale, Bull. de la Soc. d'Anthropologie, Paris, 1879, 3e Sér., Pl. op. p. 470.

Among the many expedients which used to be employed for estimating population was that of multiplying the number of living in which one death was supposed to occur, by the number of deaths. That is to say, by guessing at a factor which could only be ascertained by comparing the annual deaths with the number living. Take, for example, the estimates of the population in London made by Graunt in 1662 on the basis of one death occurring out of every 32 living, which made the population to be 403,000. In 1683 Petty, taking the mortality to be 1 to 30 persons living, made the population to be 669,930.



One peculiar thing about this method is, that it is liable to make the population seem the largest at those periods when it was in reality the smallest; for when the number of deaths was unusually large by reason of an epidemic, which would actually lessen the number living, it would show an apparent increase in the population for the same period.

It may, perhaps, be asked why it is, if the nature of the data which are required to make mortality statistics reliable and satisfactory is so well known, that more of them are not provided by the municipal and State Officers charged with the registration of vital statistics. For example, New York City has a very perfect system of registration of deaths, which is in competent hands and is well executed. Why, then, has New York City published no separate mortality report since 1883, and why, in the reports which it has published, does it not give the data with minuteness of grouping so that we might know the number of deaths at each age, of each sex, and of each race and occupation in each ward from each cause of death, instead of giving, as it gave in its last report, the number of deaths from each of certain causes of death for each of a few groups of ages, and separately for each sex, and for natives of the United States, natives of foreign countries, and colored; to which is added a statement of the deaths from zymotic diseases in each ward?

In order to understand the answer to this, it is necessary to have a clear conception of the difference in cost of tabulation and publication according to the mode of grouping of the data. If, for example, the deaths are given by twenty groups of ages and by sex and by color for each of the 24 wards, and for the city as a whole, it will require 49 columns to do this. If we make the distinction for, say, 100 different causes of death, allowing fifty lines to the page horizontally, and twenty columns vertically, giving 1,000 places per page, we should get all this information for the city on four pages; but if we wish to show the number of cases of death from each cause at each group of ages, of each sex and each color in each ward, we shall have to have 2,000 columns, which will make about 200 pages. If it be desired to estimate the influence of seasons in connection with all these things, we must have a similar table for each month, or 2,400 pages large octavo.

Again, let us suppose that we wish to have the data fully presented in order to estimate the influence of occupation upon health. We will only ask for details of one hundred occupations in males. But we should like to know the number of deaths in each of these occupations for each of, say, ten groups of ages, in each of at least five races, in the married and single, in each of twelve months, for each of the twenty-four wards, for each of, say, 100 different causes of death, giving 288,000,000 possible places, making 288,000 pages large octavo.

It is, of course, out of the question to present the data in any such detail as this, and it is therefore necessary to make a selection of combinations which will indicate the most interesting relations of the several points under discussion.

It is, however, often very difficult, and even impossible, to tell precisely what combinations it will be necessary to make to get at the probable explanation of an especially high or low death-rate in a given group; and hence we sometimes have to make a very considerable number of tentative combinations and tabulations, from which we may select only a few as really throwing light on the matter, and therefore as worth publication.

When we have to tabulate data in such a way that the individual items are to be distributed through a thousand columns or more, and each of these to be summed up for different localities, a vast amount of clerical labor is required. For distributing in 1,000 spaces the various items assigned in each death-certificate, if it be done by the old-fashioned system of tallying on a large sheet, an expert clerk will not be able to tally off more than 1,000 records of death per day; so that for, say, 30,000 deaths, which is less than the average number of annual deaths in New York City for the last ten years, it would require the labor of a clerk 30 days to produce a single page table, about one per cent. of what is needed.

By the use of cards or slips, tallying machines, adding machines, and sorting boxes of various kinds, this labor may be much reduced. One of the latest methods of doing this is by the use of cards of a uniform size, in which holes punched in certain parts of the card correspond to the various divisions of locality, time of death, sex, age, occupation, cause of death, marital condition, etc. These cards may then be passed through a machine which registers on a series of dials such combinations of the data as the dials may be adjusted for, by means of electrical connections established between a metal plate below and a series of metal rods above, wherever there is a hole in the card.

Death-rates, even when derived from complete and accurate data and compiled in the most satisfactory manner in the form of life-tables, necessarily give only an imperfect view of the prevalence of disease in a community, or of the relative amount of disability among the people, requiring extra labor by the productive class due to the recurrence of sickness. Many forms of disease which render life more or less of a burden, and some of which totally disable the individual from earning his subsistence, seldom or never appear in the registers as a cause of death; while even of those diseases which are reported as causes of a considerable proportion of deaths, we can rarely at present indicate any definite or certain relation between the number of cases of the disease and the number of deaths reported. For example, it is well known to all practising physicians that the mortality varies greatly in different epidemics of such diseases as scarlet fever, measles, small-pox, whooping-cough, yellow fever, etc., the variations appearing to depend principally upon the particular conditions of the environment as to temperature, moisture, winds, density of the population, etc., at the time of the outbreak, and also upon particular conditions of the specific virus or micro-organisms causing diseases of this kind.

Take, for example, the spread of yellow fever in Texas and along the Gulf Coast during the year 1867. Here the specific cause of this disease appears to have entered the United States by two distinct routes, one coming from Vera Cruz, Mexico, and the other coming from the usual

source, Havana. At that time the United States had a comparatively large number of troops along the Southern border of the country, and hence we have a series of returns showing not merely the number of deaths, but also the number of cases of sickness from this disease occurring in a given population.

Now, in those places where the disease was of Mexican origin the cases were more fatal than those of Cuban origin, "two out of every five cases of the former dying, while the mortality of the latter was only two out of seven. The ratio of deaths was 400 per 1,000 cases for the first of these groups, 284 per 1,000 for the second."[1]

For the great majority of diseases it is not possible to obtain statistics as to their prevalence among a general population. The only sources to which we can look for information of this kind are the records of the Army and Navy, of the police force in certain cities, of the employés of railroads, and of the members of certain societies having insurance against sickness. The records of the Army and Navy are especially valuable in this point of view, but they relate only to males of certain groups of ages and of a carefully selected class of population.

In the last United States Census an attempt was made to obtain on the schedules of the living population the number of those who on the first day of June, 1880, were so sick or disabled as to be unable to pursue their ordinary occupations. This was the first attempt of the kind which has been made in this country, but similar attempts were made in two censuses in Ireland, in a census of the Australian Colonies, and in a census of Hungary.

The first examination of the United States schedules seemed to show that the returns of the sick were too imperfect and too inaccurate to permit of drawing any conclusions from them. But subsequently it turned out that they were really more complete than had been supposed, and a sufficient number were compiled for different parts of the country to obtain a fair sample of the general results. This compilation showed that for the total population over fifteen years of age the number found sick out of every 1,000 living varied from 7.17 to 22.7 for males, and from 8.1 to 17.5 for females, or about 1⅓ per cent of males and 1⅓ per cent of females. These do not include the blind, deaf and dumb, insane and idiots, and it is probable that the figures do represent very fairly the different proportions of sickness occurring in males and females, and in certain groups of ages at the time that the census was taken, which, it must be remembered, was at a period when there is probably the least amount of sickness and disability among adults.

From the results of data derived from mutual benefit societies in England it has been estimated that for every case of death in a community there are two persons constantly sick; that is to say, there is an average of two years sickness to each death, or that if the annual death-rate is 18 per 1,000 the average number constantly sick is about 36 per 1,000.[2]

By the census reports the proportion of sick to 1,000 of population of different ages was as follows:

Age.	Males.	Females.
15 to 25	6.9	6.8
25 to 35	8.6	9.7
35 to 45	12.2	11.5
45 to 55	16.8	14.4
55 to 65	25.5	20.4
65 and over	44.5	35.3

[1] War Department, Surgeon-General's Office, Washington, 1886: Circular No. 1., page xviii.

[2] Mr. T. R. Edwards (London Lancet, 1835-36, i., p. 855), from the study of a series of returns from friendly assurance societies, claimed that, for large numbers of people, there is a constant ratio of sickness peculiar to each age, and that the duration of each case of sickness at any age is in proportion to the mortality at that age. His theory is that the mortality at any year of age exceeds that of the preceding year by 2.999 per cent., or that the mortality during any decennial interval of age exceeds that of the preceding decennial by one-third part; or that the mortality rate doubles in 23⅙ years. According to his theory, if a physician loses by death double the proportion of patients at the age of forty-three that he does at the age of twenty, the effect of his remedies in each case is the same.

This corresponds, in a general way, to the conclusions of Mr. A. G. Finlayson relative to the amount of sickness in members of friendly societies, printed in 1854.[1]

He found that, taking the whole mass of male members of friendly societies, from the age of 15 to that of 85, about five years of sickness occurs to each man during this 70 years; but during the period of labor, from the commencement of the sixteenth year of age to the close of the sixty-sixth, there are in this 51 years but 78 weeks of sickness, or about one and a half week per annum; and the sickness occurring from 42 to 66 is almost double that occurring in the first half from 15 to 41. Hence he concludes that the sickness of the first 25 years of working life is almost exactly one-half of that of the second 25 years. In the class devoted to heavy labor the sickness is almost a year more, or in the proportion of 11 to 9 as compared with the sickness undergone in the class engaged in light labor.

It is also to be observed that during the early years of life, say from 21 to 41, the number of persons withdrawing, or excluded from such societies, is very large, being nearly five times the number of deaths. As the age of the members increases the departures become fewer, because it becomes more of an object to remain connected with the society, since the rate of annual payments is the same for all ages, while the proportion of sickness steadily increases, as we have seen, with advancing age.

Several attempts have been made to induce physicians to keep a record of all the cases they treat, but with very little result. In 1857 the Metropolitan Association of Health Officers in London carried out a systematic registration of all cases of sickness which received attention at the public expense, as in hospitals, dispensaries, almshouses, etc. About one-half of the hospitals and dispensaries in the district contributed information, but the enterprise broke down before the end of the second year, and while results gave some interesting indications for the time as to the prevalence and progress of certain forms of epidemic disease, the records have very little statistical value, as they have no definite relation to the numbers of the population furnishing the cases of sickness.

It is very improbable that anything like complete returns of sickness will ever be obtained for any large body of the civil population. Such registration will always be confined to infectious and spreading diseases; in other words, those which are known or supposed to be preventable. In order to make a registration of this kind of any great practical value it must be continuous and compulsory. The plan of endeavoring to get the medical men of a locality to voluntarily contribute this information, even when accompanied by the offer of the payment of a fee, has produced partial and incomplete results, which become more and more incomplete as time goes on, and the first enthusiasm in favor of the new plan dies away.

The various systems of compulsory notification which have been tried are, first, to require the medical attendant only to furnish the returns to the Health Office; second, to require the householder, or head of the family, to make such returns; third, to require both the doctor and the householder to make such returns; and, fourth, to require the doctor to certify to the householder, and the latter to notify the health authorities.

The Infectious Disease Notification Bill, passed by the English Parliament in 1889, is the latest attempt to solve this difficult question.

It provides that where an inmate of any building used for habitation is suffering from a disease to which the act applies, then, unless such building is a hospital in which persons suffering from infectious disease are received, the following provisions shall have effect, that is to say:

"The head of the family to which such inmate (in this act referred to as the patient) belongs, and in his default the nearest relatives of the patient present in the build-

[1] See Insurance Cyclopedia, vol. v., p. 83.

ing or being in attendance on the patient, and in default of such relatives every person in charge of or in attendance on the patient, and in default of any such person the occupier of the building shall, as soon as he becomes aware that the patient is suffering from an infectious disease to which this act applies, send notice thereof to the medical officer of health of the district.

"Every medical practitioner attending on, or called on to visit the patient shall forthwith, on becoming aware that the patient is suffering from an infectious disease to which this act applies, send to the medical officer of health for the district a certificate stating the name of the patient, the situation of the building, the name of the head of the family or other person who appears to him to be primarily liable to give the notice under this act to the medical officer, and the infectious disease from which, in the opinion of such medical practitioner, the patient is suffering.

"Every person required by this section to give a notice or certificate who fails to give the same, shall be liable on summary conviction in manner provided by the Summary Jurisdiction Acts to a fine not exceeding *forty shillings*.

"The local authority shall gratuitously supply forms of certificate to any medical practitioner residing or practising in their district who applies for the same, and shall pay to every medical practitioner for each certificate duly sent by him in accordance with this act a fee of *two shillings and sixpence* if the case occurs in his private practice, and of *one shilling* if the case occurs in his practice as medical officer of any public body or institution."

On the part of some members of the medical profession, both in Great Britain and in this country, strong objections are urged to compulsory notification of disease, and especially to that form which requires the doctor to furnish such notification direct to the sanitary authorities. It is urged that such notification is a violation of professional secrecy; that it leads to concealment of cases of such disease and the refraining from calling in a medical attendant, and that it tends to throw the treatment of such cases into the hands of a lower class of practitioners, who are willing to run the risks of violation of the law, or, even, to make false returns for the sake of securing an increased practice. There is, however, little difficulty in keeping the information furnished strictly confidential, provided the health-officer is a man of tact and discretion, and provided, also, that the press does not insist upon being too inquisitive with regard to matters of this kind.

Any system of compulsory notification, however, which has to be continuously successful, involves two things. First, that the health-officer shall not be in any way engaged in, or connected with, private practice, so as to do away with all reluctance on the part of general practitioners reporting their private cases.

The second is that, to obtain any benefit from notification, special hospital accommodations for such forms of diseases as are reported must be provided by the community, and there must be a power of compulsory removal of patients to such hospitals in certain cases.

Undoubtedly, valuable statistical data might be obtained by the simple notification alone; but the desire to obtain statistical information will never be accepted as a sufficient ground for legislation requiring compulsory notification.

We hear very much in recent years of the proportion of deaths from zymotic diseases as a test of the salubrity or sanitary condition of a place; but as there is no general agreement as to what is and what is not a zymotic disease, and as the term rests on a theory of causation of disease which is now definitely abandoned, it should no longer be made use of. It is much better to select the mortality from certain forms of disease, and specify these, in order that we may know exactly what we are talking about and be sure that the matters compared between two localities are the same. English health-officers often use the term "seven principal zymotic diseases," by which they mean small-pox, measles, scarlet fever, diphtheria, whooping-cough, typhus fever, and enteric fever. If this is the selection it is not a good one, for it omits the diarrhœal diseases. Forty years ago, near the commencement of the speculations of Dr. Farr and Mr. Simon as to the causation of disease, nearly all of the contagious diseases were grouped together as zymotic diseases, and were supposed to be more or less connected with filth. At present we know that the cleanliness of the surroundings has little or nothing to do with the prevalence of small-pox, measles, scarlet fever, or whooping-cough; so that these, which are typical zymotic diseases, are of very little interest in connection with the question as to local causes of disease in a place, connected with uncleanliness, and to be remedied by sanitary effort.

Their relative prevalence, and the mortality due to them, is of interest in a totally different connection, and their separation involves an entirely different field of sanitary work. Such diseases as phthisis, diphtheria, and the various forms of diarrhœal disease, including cholera infantum or the summer diarrhœa of children, of England, are of especial interest as regards the field of local sanitary work in relation to sewerage, drainage, and cleanliness.

The influence of habitation upon death-rates, and on the prevalence of certain forms of disease, is indicated by statistics given by Dr. Korosi for the city of Budapest, where the deaths are reported with the following classification, viz.:

1. Persons in a habitation where, at most, two persons dwell in one room.

2. Persons dwelling where from two to five persons dwell in one room.

3. Where there are from five to ten in a room.

4. Where there are more than ten in a room.

The first class includes the rich and well to do. The others present increasing grades of overcrowding. Of each 10,000 deaths reported, 1,941 belong to the first, 5,759 to the second, 2,167 to the third, and 133 to the fourth; and these ratios may be used to compare with the proportions of deaths from any disease or group of diseases as occurring in the different classes.

Comparisons thus made indicate that contagious diseases, with the exception of scarlatina and typhus, are more frequent and more fatal in the crowded houses, and that the same is true of congenital debility and diarrhœa, while tuberculosis and pneumonia do not seem to be especially influenced by this cause. (?!). As the figures of death in these categories are not comparable with those of the living population, the results have not much value.[1]

Suppose, now, that we are studying the death-rates of a city for a series of years in order to determine whether its sanitary condition is, upon the whole, improving; whether work which has been done in the way of introducing sewerage, or improved water-supply, or special precautions in dealing with contagious diseases, have had an evident good effect, and have produced results which are, on the whole, satisfactory in proportion to their cost. It is very evident that we must have something more than the mere gross death-rates for the whole population in order to form an intelligent opinion on these points. A gross death-rate may, it is true, give a correct answer to the question as to whether the sanitary condition is improving, but we can never be sure of the correctness of this answer until we have made detailed comparisons of the mortality by age and sex, and of that due to certain great classes of disease.

What has been the influence of modern civilization upon the average duration of human life? upon rate of increase of population? upon the average health and vitality of the races which it has affected? The present population of the world is between one thousand five hundred and one thousand six hundred millions, of which there are in Europe over three hundred and fifty millions, and of

[1] Korosi: Influence des habitations sur les causes des décès, etc. Paris, 1877.

European stock in other countries one hundred millions; in all, say, four hundred and fifty millions, as against one hundred and fifty millions in 1788.[1]

Evidently the birth- and death-rates now prevailing in Europe and the United States cannot have long continued, for if we suppose a population to double itself only once in a century, a million of people, living one thousand two hundred years ago, would have developed into a population of over four thousand millions by this time.

What, then, is the difference between the expectation of life in New York at the present day and that in European cities one, three, five, ten, or twenty centuries ago? This question has been asked in various shapes many times, and many attempts have been made to answer it; the general conclusion being that there has been a very grea increase in the average longevity of man in civilized countries, not only within the last thousand years, but within the last century. Notwithstanding, it must be confessed that the statistical records bearing on this point are very incomplete, vague, and unsatisfactory, and that it is only for the last forty or fifty years that we can speak with anything like scientific precision as to the amount of progress made.

So far as what is termed potential longevity, that is to say, the maximum duration of life possible in an individual of the race, is concerned, there is no evidence that this has changed for at least two thousand years, being for man generally taken as one hundred years. You will remember the scriptural declaration that the years of a man are threescore years and ten, and though by reason of strength they be fourscore years, yet is their strength labor and sorrow; notwithstanding, there are sufficient records to prove that even in those days the potential longevity of man was as great as it is at present.

But when we come to the average longevity and expectation of life at birth, there is sufficient evidence to indicate that it has increased; but whether this is due to the preservation of more infant-lives for a few years, although they may still die before the productive period is reached, or to an increase of the number of those who live into and share the working period of life, is still uncertain, for this question can only be settled by comparative life-tables, and I have already explained that we have no reliable life-tables that are much over fifty years old.

I have already referred to the average duration of life among the better class of Roman citizens as fixed by Ulpian, being equal to thirty years. Among the oldest data which we possess, from which we can attempt to compare death-rates of past centuries with those of the present, are the records of Geneva in Switzerland, which date from 1551. The average annual death-rate per 1,000 was as follows:

From 1551 to 1600	40
From 1601 to 1650	37
From 1651 to 1700	35
From 1701 to 1750	33
From 1751 to 1800	29

From 1801 to 1813 the mean duration of life was thirty-six years and six months.

From this, the probable duration of life is given as follows: [2]

Periods.	Probable duration of life. Years.	Months.	Days.	Proportionate increase.
End of the sixteenth century	8	7	26	100
End of the seventeenth century	13	3	16	153
1701 to 1750	27	9	13	321
1751 to 1800	31	3	5	361
1801 to 1813	40	8	0	470
1814 to 1833	45	0	29	521

The figures are not sufficiently full or accurate to justify the conclusion that the probable duration of life in this place has been increased five times in three centuries, but they do indicate a very marked and progressive increase.

[1] See Giffen, Jubilee Volume of Statistics, 1885, p. 99.
[2] Mallet: Annales d'Hygiène, 1837, vol. xvii., p. 5.

In the sixteenth and seventeenth centuries Geneva had a small population, frequently exposed to fatal pestilence, and produced a comparatively large number of infants, of whom but a very small proportion reached the age of puberty.

In the early part of the eighteenth century the average mortality of all European countries, taking towns and villages together, is estimated by Süssmilch as 1 in 36, or 27.778 per 1,000.

The most important contributions to our knowledge of the increase in the duration of life in recent years is contained in a paper on the decline in the English death-rate, by Noel Humphreys, published in the *Journal of the Statistical Society*, in 1883; and in a report by Dr. William Ogle, in a supplement to the Forty-fifth Annual Report of the Registrar-General of England, published in 1885.

The conclusions, as based upon English life-tables, comparing periods from 1838 to 1854, and from 1871 to 1880, are as follows:

The mean after-lifetime of a male at birth was for the first period 35.91 years, for the second, 41.35, showing an average gain of nearly a year and a half. The mean after-lifetime continues longer in the second period than in the first for each year of life until the nineteenth. At the close of the nineteenth year the expectation of life was exactly the same in each period, viz., 40.17 years. From that time onward the after-lifetime is shorter in the recent period than in the older one; that is to say, the individual male in England lives on an average a shorter time after he is nineteen years old than he did forty years ago; but the number of males out of equal numbers at the start who survive to live these shorter lives is very much greater than it was formerly, so that the aggregate life of the whole is considerably increased. The gain is greater in females than in males. Thus in the first period the expectation of life in females was 41.85, while in the second period it was 44.62, being a gain of 2.77 years on an average for each female. The after-lifetime continues longer in the new period down to the completion of the forty-fifth year, when the expectation of life becomes the same, viz., 24.06.

Taking a million males and a million females, the following table shows the additional years gained at each age-group, for each sex, during the recent period.

Age periods.	Males.	Females.
0 to 15	255,340	288,226
15 to 25	281,872	339,933
25 to 35	344.906	453,221
35 to 45	310,746	499,471
45 to 55	211,040	474,009
55 to 65	86,920	385,257
65 to 75	10,464	239,617
75 to 85	27,770	89,568
85 and upward	13,451	8,282
Total years gained	1,439,139	2,777,584

This table shows plainly how erroneous is the conclusion sometimes drawn that, because the death-rates have fallen only in the earlier age-periods, while they have risen in the later age-periods, the aggregate gain to the community from the changes is confined to the unproductive years of life. We may fairly take the period which intervenes between twenty-five and sixty-five years of age to be the most valuable part of life, and of the aggregate years saved, 66 per cent. in the case of males and 65 per cent. in the case of females are lived in this period.

The earliest attempt to give vital statistics for the United States is probably a paper by Edward Wigglesworth, published in the "Memoirs of the American Academy of Arts and Sciences," 1793, vol. ii., page 131, entitled "A Table showing the Probability of the Duration, the Decrement, and the Expectation of Life, in the States of Massachusetts and New Hampshire, formed from Sixty-two Bills of Mortality on the Files of the American Academy of Arts and Sciences in the Year 1789." The whole number of deaths reported on these bills was 4,893.

He had no data of population, but the reports indicated that the births in the locality sending the bills were twice as many as the deaths. As his calculations are based solely on the deaths alone at certain ages, the conclusions are evidently entirely unreliable; but, such as they are, they are as follows:

The expectation of life at birth was 28.15 years; at five years, 40.87; at ten, 39.23; at fifteen, 36.16; at twenty, 34.21.

By another calculation he finds that the expectation at birth was 35.47, and at five years of age 48.46.

Another paper is by J. E. Worcester, printed in the "Memoirs of the American Academy of Arts and Sciences," Philadelphia, 1833, vol. i., New Series, page 1, and entitled "Remarks on Longevity and the Expectation of Life in the United States, relating more particularly to the State of New Hampshire." Taking the bills of mortality of thirty-two townships in New Hampshire for an average length of time of twenty-one years, he found that the death-rate was 1 in 83, or 12.04 in 1,000. He wisely remarks that the ratio is so small as to excite suspicion concerning the accuracy of the bills.

With this may be contrasted the following table showing the expectation of life in Massachusetts as computed from the deaths occurring in the five years 1883–87, compared with the living population in the middle of this period as deduced from the Massachusetts census of 1885.

and, therefore, that the increase of mankind may be considered as the chief source of misery, which misery, together with moral restraint to a limited extent, and vice, check the superior growth of population, keeping it at a level with the means of subsistence.

If this doctrine be applied to the lower animals or to an extremely savage and ignorant set of men, it is very nearly correct; for, in this case, the term "means of subsistence" applies almost exclusively to the natural produce of the earth. As soon, however, as man applies his intelligence to the increase of the means of subsistence by improvements in agriculture, by manufactures, etc., it is no longer true that the means of subsistence increase in an arithmetical proportion. They may increase, and, for the last fifty years have, throughout civilized regions of the world, actually increased in a ratio more rapid than geometrical proportion and more rapid than the increase of population; and it is, therefore, substantially true that "the character of every race of men is the real limit to its numbers in the world, if allowance be made for accidents of position and time."[1]

The uneducated and unskilled laboring classes who are without capital, when gathered together in large masses, tend constantly to illustrate the theory of Malthus by increasing faster than they can provide means of subsistence for themselves and their families.

But this tendency is opposed by the advance in knowl-

Expectation of Life.

Ages.	Massachusetts, 1883–87.			City of Baltimore, 1880.						New York City, 1879–81.		
	White and Colored.			White.			Colored.			White and Colored.		
	Persons.	Male.	Female.	Persons.	Male.	Female.	Persons.	Male.	Female.	Persons.	Male.	Female.
0	40.87	39.72	42.03	38.18	36.49	39.86	23.26	21.00	25.51	30.90	29.04	32.77
1	49.77	49.43	50.12	46.04	44.73	47.36	35.32	32.20	38.44	39.66	38.22	41.09
2	52.67	52.36	52.98	49.80	48.42	51.18	41.91	39.25	44.57	44.04	42.59	45.49
3	53.02	52.73	53.31	51.05	49.77	52.33	43.66	41.19	46.13	45.39	43.93	46.85
4	52.96	52.70	53.23	51.58	50.27	52.90	44.07	41.84	46.30	46.08	44.62	47.55
5	52.70	52.43	52.97	51.72	50.46	52.99	44.32	41.84	46.79	46.28	44.85	47.71
10	49.61	49.27	49.95	49.66	48.50	50.83	42.40	40.06	44.75	43.84	42.40	45.27
15	45.53	45.13	45.94	45.46	44.35	46.58	39.42	36.84	42.00	39.70	38.24	41.15
20	41.93	41.41	42.45	41.50	40.36	42.65	36.62	33.76	39.47	35.84	34.41	37.28
25	38.76	38.24	39.28	38.06	36.86	39.27	33.68	31.02	36.34	32.56	31.18	33.95
30	35.54	34.94	36.15	34.74	33.45	36.04	30.64	27.76	33.53	29.64	28.24	31.04
35	32.33	31.65	33.02	31.42	30.04	32.81	27.62	24.51	30.72	26.71	25.29	28.13
40	28.98	28.26	29.71	28.05	26.70	29.40	24.68	21.71	27.64	23.89	22.54	25.24
45	25.64	24.88	26.41	24.67	23.35	25.99	21.74	18.91	24.56	21.08	19.80	22.35
50	22.29	21.55	23.04	21.27	19.96	22.58	18.92	16.26	21.58	18.26	17.16	19.36
55	18.95	18.23	19.68	17.86	16.56	19.16	16.10	13.62	18.59	15.44	14.51	16.36
60	15.98	15.32	16.64	15.01	14.06	15.96	13.42	11.29	15.54	12.98	12.20	13.76
65	13.01	12.42	13.60	12.17	11.57	12.77	10.72	8.96	12.48	10.52	9.89	11.15
70	10.74	10.27	11.21	10.24	10.09	10.40	8.87	7.80	9.94	8.90	8.47	9.34
75	8.47	8.12	8.83	8.32	8.61	8.03	7.02	6.65	7.39	7.29	7.05	7.53
80	7.24	7.03	7.45	7.14	7.39	6.38	6.90	6.26	6.49	6.38	6.22	6.54
85	6.00	5.94	6.07	5.98	6.17	5.78	5.72	5.86	5.59	5.46	5.39	5.54

One of the most frequent fallacies in the use of statistical data is to mistake an effect or a coincidence for a cause. For example, it is common to speak of rapid growth in population of a locality or country as if it were in itself a good and desirable thing, a cause of prosperity and well-being, and when this growth lessens or ceases we find some philosophers trying to devise ways and means to increase it. This, for example, has been the case in France for a number of years, and various plans have been proposed for increasing the birth-rate and diminishing the death-rate, in order to produce prosperity and strength in the country. The fact is that rapid increase of population in a country is an indication that things are going on well there, that there is a demand for labor, and that men find that they can increase their comfort by going, or staying, there; but it may, or may not, be a cause of prosperity at a given time, and sometimes it may cause hardship, weakness, and suffering.

You are all, no doubt, familiar with what is known as the Malthusian theory, which is, essentially, that population is limited by the means of subsistence available, that population increases in a geometrical proportion, while the means of subsistence do not increase in a faster ratio than arithmetical progression; that, therefore, the growth of population is checked by want of means of subsistence,

edge, increase in energy, and improvement in inventions in the educated classes, who, although it may be said that they are acting only from selfish interests, are, nevertheless, led by those interests to expand the fields of agriculture, manufactures, and commerce, and, thus, to both increase the means of subsistence and to lessen the price thereof.

Under favorable conditions a population is capable of doubling its number every twenty-five years. In the United States, between the years 1790 and 1860 the population doubled itself about once in 23½ years. But a proportion of this increase was due to immigration.

Whether in the future a systematic attempt to maintain an equilibrium between subsistence and population will become a practical problem of national policy is, at present, a purely theoretical speculation, for it is very easy to show, as has been done by Mr. Atkinson, that the means of subsistence at present at our command can easily be quadrupled, as the increase of the population occurs to both require and produce such increase.

Note.—In estimating the progress of the population of the United States for the next century, if we assume a rate of 33.3 per cent. of increase in ten years, which is a

[1] Farr: Vital Statistics, London, 1885, p. 15.

little less than the mean rate for the last century, we find that the probable population in 1990 will be 1,206,562,-248, giving a density of population of 399 to the square mile, approaching the present density of China, which is 420, or of Belgium, which is 434 per square mile.

NOTE.—Maria Mitchell, in a recent number of the *Century*, speaking of an interview with Sir John Herschel, says that, one morning at the breakfast-table, Herschel put the following question: Suppose that since the time of Cheops, three thousand years ago, man had only died from natural decay at about ninety years of age, and that the population doubled itself every thirty years; starting with a single pair at the time above referred to, would the present surface of the earth afford standing room to the entire progeny if closely packed? The replies to this conundrum were various; one saying that they would occupy a layer three feet deep, another a layer fifty feet high, and so on, extending the guesses as he said, " More, more," to the distance of the moon, to the sun, and finally to the planet Neptune, when his reply was that they would have piled up upon the surface of the earth to a distance equal to one hundred times the distance of the earth from the planet Neptune.

One of the most interesting and important questions in vital statistics in this country is that relating to the relative increase in the white and colored population in the Southern States, and the influence which has been, and will be, exerted upon this by the abolition of slavery. On the one hand, it is claimed that the large increase in the colored population between 1870 and 1880 indicates that in fifty or, at most, a hundred years more it will greatly predominate.[1] On the other, it is affirmed that the greater increase of the colored population is apparent rather than real.

The following table will aid in forming an opinion on this point; but we must wait until we know the results of the next census before coming to any conclusion.

births, deaths, and marriages begin with the year 1853 and end with the year 1859. In neither State was the registration of either births or deaths in any year sufficiently complete to permit of accurate comparisons with the number of living population, either for the whites or blacks.

The conclusions drawn by the registrars may be summed up in the statement that the birth-rate of the slaves was much greater than that of the whites in South Carolina, while the difference was not marked in Kentucky; that in both States the death-rate of the negro was decidedly greater than that of the whites, especially in infancy, and that the average age at death was decidedly higher in the whites.

I have already shown the fallacies connected with taking the average age at death as a means of judging either the healthfulness of a locality or the expectation of life. Notwithstanding, this is practically the only ratio to which we can refer in regard to the question under consideration. In the last South Carolina report for 1859 the proportions are as follows:

One birth in a population of	48.27 whites.
" " " " "	26.05 slaves.
" " " " "	32.34 of both races.
One death in a population of	136.82 whites.
" " " " "	59 20 slaves.
" " " " "	77.95 of both races.
Average age at death	28.42 years in whites.
" " " "	14.87 years in slaves.
One marriage in a population of	169.90 whites.

In the last Kentucky report it is stated that the average age at death was, for the whites, 21.21 years, and for the blacks, 18.27 years.

The records of the statistics of 1880 show that the birth-rate for the year was greater in colored than in the whites; since in the ten groups in which distinction of color was made for this purpose the birth-rate for the whites was 32.0, and for the colored, 38.06, per 1,000 of aggregate population; or for the whites, 127.1, and for

Table showing Percentage of Increase of White and Colorea Population in Certain Districts.

District.	1840–50.		1850–60.		1860–70.		1870–80.		1850–80.		1860–80.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
I.	20.92	9.47	18.72	7.24	11.35	4.16	26.54	27.57	67.28	42.42	40.90	32.88
II.	35.73	27.16	33.15	14.50	29.49	3.91	24.77	23.74	115.60	47 23	61.54	28.58
III.	23.30	29.17	17.08	18.43	3.98	10.85	30.19	34.56	36.92	72.66	35.37	49.17
IV.	....	....	67.90	59.32	14.79	9.43	62.90	46.79	213.90	155.90	86.97	60.63
Total	26.96	19.73	30.13	22.47	16.90	7.67	32.87	34.38	102.14	77.20	55.33	44.68

District I. includes Delaware, Maryland, District of Columbia, Virginia, West Virginia, and North Carolina.
" II. " Kentucky, Tennessee, and Missouri.
" III. " South Carolina, Florida, Alabama, and Georgia.
" IV. " Mississippi, Louisiana, Arkansas, and Texas.

In examining these figures it must be remembered that the census of 1870 was very imperfectly taken in many of the Southern States, and that the apparent great increase in the negro population is largely due to the incomplete enumeration of the negroes in 1870. Hence I prefer to compare the period 1840–60 with 1860–80, instead of using the ten-year periods. It is also to be remembered that migrations have affected the whites more than the negroes. Many more whites than negroes have left Group III., and the increase of population in Texas is largely due to white immigration.

We have little information of value relative to the vital statistics of the colored population in the South previous to the abolition of slavery. The only two Southern States having registration laws which were to any extent enforced were Kentucky and South Carolina. The Kentucky reports relating to the registry and returns of births, marriages, and deaths are eight in number, commencing January 1, 1852, and extending to December 31, 1859, the last report being printed in the early part of 1861. The South Carolina annual reports of registration of

the colored, 163.8, per 1,000 of women between the ages of 15 and 49. The birth-rate is always higher among the poorer classes of a population, and it is doubtful whether the birth-rate of the negro is higher than that of the laboring classes among the whites. The mortality among the colored infants in the earlier months of life is much heavier than among the whites in the same localities. For example, in the ten grand groups just referred to, out of each 1,000 infants born the number which died under six years of age was, for the whites, 66.7, and for the colored, 71.4. This fact tends to increase the birth-rate among the colored, because with the loss of the infant, and consequent cessation of nursing, the probabilities of a fresh pregnancy increase. The marked difference between the vital statistics of the white and colored in the South is much greater in the cities than in the rural districts, as will be seen from the following table.

The average mortality in a population of a little over 43,000,000 whites was recorded as 14.74 per 1,000; while in a population of 6,752,000 colored the recorded mortality was 17.28 per 1,000. It is known that each of these recorded death-rates is much lower than the actual one, owing to failure to record the whole number of deaths

[1] See paper by E. W. Gilliam, Popular Science Monthly, xxii., 433.

occurring during the census year; but it is also known that the proportion of failures to record was decidedly greater among the colored than among the whites, and hence the difference between the death-rates of the two races is even greater than that indicated by these figures.

two races under comparatively similar circumstances than we now have.[1]

The data are insufficient to bear out any definite conclusions and the above can properly be put in the form of questions only.

Birth-rate per 1,000 *of Living Population.*

	Aggregate population.		Birth-rate per 1,000 of living population.		Increased percentage of colored births.	Increased percentage in urban over rural counties.	Born and dying during census year per 1,000 births.		Increased proportion of colored infants born and dying during census year.	Increased proportion in urban over rural counties.
	White.	Colored.	White.	Colored.			White.	Colored.		
Twenty-three counties in the South containing cities and large towns.	588,129	586,038	28.71	35.08	6.37	1.22	100.01	140.06	40.05	11.66
Fifty-one counties in the South containing very small towns	542,705	591,336	34.31	39.46	5.15	...	62.66	91.0	28.39	. .

How far is this excessive mortality in the colored population due to race characteristics? Is it due to peculiar susceptibility on the part of the negro to certain distinctive forms of disease, or to his having less vital force and capacity to resist disease and death? Undoubtedly the great mass of the colored population is poor and ignorant, lives in the dampest and dirtiest parts of cities, and in the midst of unhealthy surroundings, and is in other respects unusually exposed to well-recognized causes of disease.

The statistics of 1880 show that the colored race is peculiarly liable to fatal results from certain forms of disease, especially consumption, pneumonia, diarrhœal diseases, affections of pregnancy, scrofula, and venereal diseases; and that, on the other hand, it is much less liable than the white race to fatal results from cancer, diphtheria, diseases of the nervous system, scarlet fever, and suicide.

Notwithstanding the interest and importance of the question, we have at present no sufficient data to determine whether the negro, under the same circumstances as to poverty, etc., is, or is not, more prolific or short-lived than the whites, and absolutely no data of any value for determining the relative fecundity and mortality of the mixed bloods, including mulattoes, quadroons, octoroons, etc. An effort will be made in the coming census to supply this deficiency as far as possible. In the enumeration of the population those of mixed blood will be recorded separate from the pure blacks and the pure whites, and an effort will be made to obtain corresponding records of death in order to determine the death-rates of these mixed bloods. An effort will also be made to determine the birth- and death-rates of certain classes of poor and ignorant whites, such as the tenement-house population in our Northern cities, as distinguished from those of the mass of the white population, which will give us a better means of comparison of the mortality of the

Annual Rate of Mortality in Various Classes of the Population of Dublin at Different Age-periods during the Four Years 1883–1886.

Occupation or social position.		AGE.					
		All ages.	[illegible]	5	20	40	60 and upward
All persons	Years of life.......	1,406,124	151,853	400,111	490,174	260,459	103,527
	Deaths	39,476	12,365	3,535	6,519	7,652	9,405
	Rate per 1,000	28.07	8.143	8.84	13.30	29.38	90.85
Professional and independent class................	Years of life.......	122,198	9,113	28,950	37,832	26,987	19,316
	Deaths	1,857	187	85	237	350	998
	Rate per 1,000	15.20	20.52	2.94	6.26	12.97	51.67
Middle class..................................	Years of life.......	230,212	25,097	73,439	84,535	36,077	11,064
	Deaths	6,034	1,462	587	1,171	1,073	1,741
	Rate per 1,000	26.21	58.25	7.99	13.85	29.74	157.36
Artisan class and petty shopkeepers..............	Years of life.......	430,493	52,299	129,588	141,909	79,705	26,992
	Deaths	9,902	3,611	1,123	1,621	1,883	1,664
	Rate per 1,000	23.00	69.05	8.67	11.42	23.62	61 65
General service class, including workhouse inmates.	Years of life.......	623,221	65,344	168,134	225,898	117,690	46,155
	Deaths	21,683	7,105	1,740	3,490	4,346	5,002
	Rate per 1,000	34.79	108.73	10.35	15.45	36.93	108.37

In studying the causes of disease and death in communities, a very important point to be considered is the relative poverty, ease, or luxury in which different parts of the population live—or the sickness and death-rates of so-called social classes.

That extreme poverty, producing inability to obtain the amount of food, clothing, and shelter requisite to preserve health is a direct cause of high death-rates, especially in Northern climates, is known to all; but the extent to which this factor of want influences the death-rates in different countries or communities is by no means easy to determine, and thus far we have, for the most part, only data bearing indirectly upon this subject. For the provident and presumably well-to-do classes we have the statistics of life-insurance companies; but these are for selected lives, which fact tends to give a low death-rate during the early years of the policy-holders, while, on the other hand, the tendency to cease paying annual dues and to give up the insurance is greater in those who are well and strong than in those who have reason to suspect that they are diseased, so that the death-rates in the greater ages are higher in the insured than in those not insured. We can only draw some inferences from the vital statistics of occupations, from tenement-house statistics, etc.; but it is very difficult to distinguish between effects of density of population, occupation, race, intemperance,

[1] Dr. Berenger-Feraud, in a note on the fecundity of the mulattoes of Senegal, published in Revue d'Anthropologie, 2d Series, vol. ii., 1879, page 577, gives the details with regard to the offspring of 118 females of mixed blood, and concludes: 1st, That the union of a white man with a negress in Senegal produces children apparently of good health; 2d, the offspring of these mulattoes between themselves, when there is no further intrusion of pure black or white blood in the descent, gives children who are usually sterile; 3d, when there is a new addition of white blood after the first generation, the offspring are less vigorous, the number of the girls becomes greater than that of the boys, and the girls are often sterile with a strong tendency to abortion.

uncleanly habits, and actual want of the necessaries of life.

One of the latest systematic attempts to enumerate the population of a city by social classes, and to obtain corresponding reports of deaths so as to give death-rates, is that made in Dublin by Dr. Grimshaw, the results of which are shown in the table opposite.[1]

In this connection may be mentioned the statistics collected by insurance companies among the Quakers or Society of Friends, both in England and in this country.

In 1830 Mr. Robert Rankin published a table showing the probability of life among the Society of Friends in the city of Bristol, England.

The superior expectation of life shown in this city led to the establishment of a Friends' Provident Insurance Institution in the following year, due to the belief that the members of this society had a superior longevity; but the parties concerned, with their usual business sagacity, did not invest money on a mere belief. They set to work and collected all the registers of Friends in different parts of the kingdom, with births and deaths, from which a table [2] was prepared showing that at birth the expectation of life was:

At 5 years	41.8
At 10 "	45.3
At 15 "	42.1
At 20 "	39.2
At 30 "	33.3
At 50 "	21.2
At 60 "	14.7

[1] From British Medical Journal, 1887, vol. ii., p. 343.

[2] See Insurance Cyclopedia, vol. v., p. 144; also table on p. 147, comparing expectation of life of Friends with those of the general population, and showing a decidedly higher average for the former. Compare with this, on p. 150, the mortality table for the Society of Friends in Philadelphia, prepared by Chase, in 1875.

The tendency now is to accumulate the best and the worst of the race in the cities. They draw to them the most enterprising, vigorous, and prudent, whose tendency is to late marriages and few children, and thus tend after a time to lower the standard of the race. "Where the tendency is to replace a feeble and lower race by a better one there is progress, where the tendency is the reverse there is decay. The hope that by increased knowledge, charity, and co-operation, the feeble, the sickly, and incompetent can be so cared for that they shall become strong and vigorous, is that held by most men of the present day, but there is nothing in the laws of heredity which gives any foundation for this hope."

What is to be the outcome of this modern civilization? "Its enemies are not without but within—not savage nations on its borders, but dwellers in its own cities." The general tone of modern European literature is pessimistic as to the future, filled with doubts and fears as to what the coming supreme democracy will do. In this country it is more hopeful, and looks forward to progress in improvement in the physical conditions of the race, though admitting the dangers and difficulties which this very physical improvement tends to produce. But, whatever be the views of individual thinkers and writers, on one point all can agree, and that is as to the desirability of having at our command definite, positive information as to the character, amount, and set of currents of this stream of human life in different countries and localities. An important part of such knowledge is that which relates to the composition of, and changes in, the population in different countries, which is the special field of vital statistics.

ON VITAL AND MEDICAL STATISTICS.

Lectures III. and IV.

Those of you who are familiar with the history of medicine in the early part of this century will remember the great anticipations which were formed and expressed by prominent physicians as to the results which might be expected from what was called the system of statistical medicine, introduced in the Paris School by Louis and his contemporaries. This was not exactly a new system, but rather an attempt to methodize an old one, *i.e.*, to present the experience of different physicians in such a way that comparisons might be accurately made, and the results mathematically expressed.

In this so-called numerical method, all the details of each case observed are to be noted as far as possible, without any special regard to whether these details may appear to the observer to have any special connection with the course of the case or its termination, or not. When a number of such cases have been collected, they are to be compared in all their details, showing, in round numbers, how many present such and such particular circumstances, and how many do not.

In order to make a useful application of this method it is, of course, necessary that the different observers shall be describing substantially the same thing; that is to say, the disease to be observed must present a definite series of symptoms so that a person properly qualified will recognize its existence without any liability to error. It should also be a disease which follows a tolerably regular and definite course, having a commencement which can be recognized. Such forms of disease include the so-called specific diseases, and acute affections of particular organs. The method is most applicable to surgical cases of all kinds, including those which come under the domain of the various specialties.

As regards details of pathological anatomy, it has been pointed out by Dr. Flint that the statistical method can apply only to those changes which can be appreciated by the senses after death, and that there being but one constant lesion found in typhoid fever, viz., the softening of Peyer's patches in the small intestine, the statistical method gives us little assistance in the investigation of the pathological condition of this disease.

We may note, however, that, if it be admitted that typhoid fever is due to a specific bacillus, as seems now to have been fairly demonstrated, and that this bacillus has been discovered and verified mainly by the application of experimental methods, it is, nevertheless, true that the results thus obtained have met with a general and prompt acceptance, mainly because the application of statistical methods to the circumstances of outbreaks of this disease in different communities are in perfect accord with the bacillus theory of its causation.

This merely illustrates the general law that the experimental and the statistical[1] methods must be used together, and that their results must be in accord, to produce full confidence in the results obtained by either alone.

The sanguine advocates of the numerical system of Louis supposed that all that was necessary to discover all the laws with regard to the propagation of any disease, and the true value of any or of all methods of treatment proposed for that disease, was simply the collection by different observers of all the data which could be obtained from individual cases, and the tabulation of these according to a certain fixed and almost mechanical system of permutations and combinations, by means of which the various symptoms are brought together in groups, in connection with the results observed, and that thus should be obtained a true scientific basis, or, as they commonly phrased it, "the science of medicine."

We can now see plainly enough that this is, from the nature of the case, impossible; that the data obtained by different men can hardly ever be made fully comparable, and that, however complete they may be, the number of factors which combine to produce such a result as the production of a particular form of disease in a healthy organism is so great that, from mere statistics of observation, we can never obtain scientific knowledge as to the relative part which each factor has taken in producing the result. This can only be done by experimental methods, in which the influence of one particular factor can be applied and those of others eliminated as far as possible; and the great advances which have been made toward obtaining a scientific basis for practical medicine within the last twenty-five years are, in the main, due to the experimental method. So soon, however, as we have, by the investigation of particular cases and by experiments, obtained a more or less probable theory as to the cause and mode of diffusion of a particular form of disease, the outbreaks of that disease in a community afford an invaluable means, in many cases, of testing the truth or falsity of the theory.

It must be admitted that the probabilities of error are much greater in medical than in vital statistics, and this for a number of reasons. The first is that no two observers examine, or interpret, a disease in precisely the same way, and hence it is extremely difficult to collect a mass of observations sufficiently large to form a basis for statistical reasoning. Those who wish to be scientifically accurate in the use of such material are usually compelled to deal with a very limited number of observations, because they cannot obtain a large number upon which they can fully rely.

The best data are, for the most part, those which lie in the field of surgical observation, since here the symptoms observed, the methods of relief applied, and the results obtained, are tolerably definite, and there is not likely to be much difference in the methods of recording them.

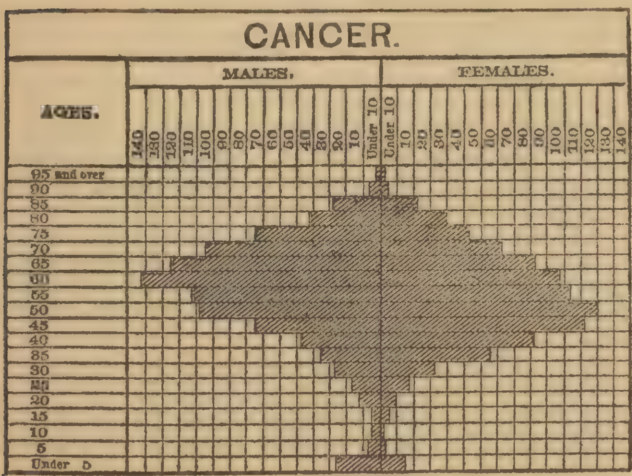
The methods of medical statistics differ fundamentally from those used by the vital statistician in that they usually have no relation to the phenomena observed in the normal, healthy, living population. The physician inquires, out of a thousand cases of children or of old persons that have been treated, how many times has this particular disease been met with; or, in a given number

[1] An interesting discussion on the value of the statistical, or numerical method, as applied to medicine, will be found in the Bulletin of the Royal Academy of Medicine for 1836, vol. i., p. 622 *et seq.* The immediate cause of the discussion was a paper by d'Amador attacking the value of the methods of Louis and criticising the results obtained. Bouillaud, Chomel, Double, and others took part in this discussion, *pro* and *con*; and while no definite conclusion was reached, it was very evident that the dispute was rather a matter of definition than of anything else.

of cases of this disease, what proportion have died? This method is, in fact, practically the only one which is available to the physician; but the vital statistician, if dealing with disease, will want to know what are the probabilities that a male between twenty and thirty years of age will contract a given disease, such as phthisis or typhoid fever, and for this purpose he wishes to know the whole number of cases observed in a given population, and the number of the population furnishing those cases, in order to establish the ratio.

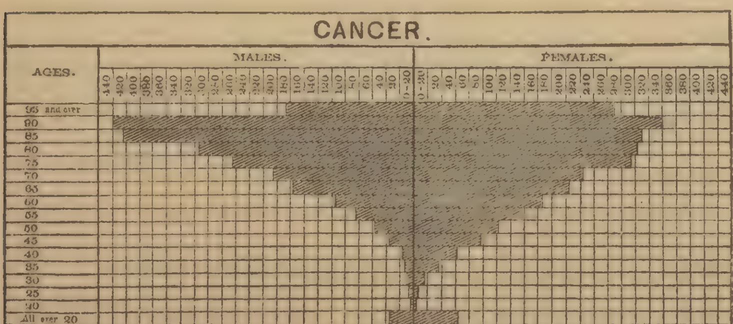
Bertillon illustrates this in his comment that the small number of deaths of old men attributed to typhoid fever might lead the physician, from his point of view, to say that typhoid fever in old age is a rare disease; but the vital statistician might conclude that the rarity of the disease in old age was simply due to the small number of those living at that period.

Deaths from Cancer at Certain Groups of Ages in 1,000 *Deaths Caused by this Disease.*



This may also be illustrated from the statistics of the 13,000 deaths reported as due to cancer in the United States during the census year 1879–80. The first of the two diagrams before you shows the proportion of deaths from cancer at different ages in the manner in which it would be calculated from the records of physicians or hospitals; namely, the ratio at each age to 1,000 deaths caused by this disease. From this diagram it would appear that cancer is most fatal about the age of sixty. If, however, we compare the deaths from cancer at each age with the total living population at that age, after the

Deaths from Cancer of Persons Over Twenty Years of Age, with Distinction of Age and Sex, in 100,000 *of Population of Corresponding Ages.*



methods of the vital statistician, we obtain the figure shown in the second diagram, which indicates that the mortality from cancer increases with advancing years to the age of ninety, and that the reason why the number of deaths from this cause diminish after sixty is simply because of the less number of living population after that age.

In discussing the tabulation of the returns of cases of acute rheumatism, in the "Collective Investigation Record," Dr. Whipham gives the number of cases in each occupation out of 655 cases recorded. Of these, 71 were domestic servants; 16, agricultural laborers; 13, farmers; 10, grocers, etc. He comments that the number of domestic servants, 71, is a remarkable occurrence, and proceeds to account for it by the consumption of alcoholic drinks, etc.

It is evident, however, that absolutely no conclusions can be drawn from these figures, since there is no definite proportion between the number of domestic servants attended by the physicians who made the reports and the number of domestic servants in existence, nor is there any relation between any of these figures and the number of domestic servants attacked by rheumatism. The only way in which this factor could be brought in in such statistics would be with reference to frequency and character of complication, or as to relative fatality of the attacks in comparison with other occupations.

The fact that in each case of sickness there are many different circumstances which combine to produce the result is not, as Louis remarks, a valid objection to the use of statistical methods for the purpose of estimating the influence and relative importance of each of these influences; it is rather an argument in favor of their employment. Counting is better than guessing, and when it gives contradictory results as applied to two groups of cases, it indicates that some circumstances have not been taken into sufficient account, and that further inquiry is necessary. In the body of the sick man, as in the test-tube, like causes under like circumstances will produce like effects.

Admitting that the chances of error in medical statistics are very much greater than in those relating to vital statistics, it does not follow that they have no value. It simply increases the desirability of collecting a large number of facts before proceeding to draw any definite deductions.

In statistics with regard to therapeutics, we have to take account of the various influences which the condition of the organism exerts upon the results before we can fairly estimate the action of the new and special influence which has been introduced in the shape of an action of a drug, or a particular mode of treatment. In any event, such statistics, even when derived from a small number of cases, serve to indicate lines of investigation, and to ask questions, if they do not answer them. As Legoyt remarks, two pneumonias do not resemble two dice, each having the same number of faces and of numbers, but rather dice with an unequal number of faces and different numbers.

The greater part of our pathology and therapeutics has not been derived from statistical observation. It is not by this means that the diagnosis of small-pox, or of scarlet fever, or of rheumatism, has been worked out, or the fact that the ulceration of the intestinal glands belongs to typhoid fever, or the presence of gummy tumors to syphilis; nor has it been by this means that the transmissibility of certain forms of disease by contagion has been proved. Whenever a necessary and logical connection between a particular cause and the resulting phenomena has been established, statistics are of little or no value in demonstrating the connection. In every case the result must follow the cause, as it does in a chemical experiment, and a few repetitions of such experiments give as great a degree of certainty as a thousand or more.

The chances of the occurrences of a certain event in relation to cause can only be mathematically calculated when the totality of the possible causes of the result remains the same under the different circumstances investigated. This is one of the chief reasons for the impossibility of drawing positive conclusions from medical statistics properly so called.

The consequent condition is one that I have already mentioned, viz., the application of the law of large numbers and the consideration of the limits of positive error.

The services rendered by statistics to medical science are by no means so great as was hoped by those who first proposed the application of this method; partly from the nature of the case, partly from the wrong application of statistical methods to groups of cases to which they are in nowise applicable. What result, in fact, can we expect from statistics applied, for example, to a number of cases of fever before the distinction between typhus, enteric, and relapsing fevers was understood?

The results of medical statistics will not apply to the treatment of any particular case. They can never prove that bloodletting should be employed in all cases of pneumonia, or that it should never be employed in any case of pneumonia. Even the results obtained from the most satisfactory medical statistics will only be found useful to the physician in directing his treatment, in the absence of any special indications in the particular case which he has before him.

The data upon which to base medical statistics must be obtained either from published records, from unpublished memoranda collected by means of correspondence, or by the so-called collective investigation methods, or from personal experience. The published data include such records of private practice as are given in journals, transactions, monographs, etc., records and statistics of hospitals, statistics of public medical services and of medical and life-insurance societies.

In many respects the crude data in the form of records of individual cases are the most reliable; but the labor of collecting and combining them is great, and we desire, therefore, to use the statistical tables prepared by previous workers, as far as they are available, for the particular inquiries which we have on hand.

Detailed reports of cases, such as are suitable for use in statistical work, are not over-plentiful. In the majority of cases the individual data are not given. We have only summary statements of tables of results. This is the case with regard to much the larger part of the great mass of reports of results of hospital and asylum practice which have been published during the last hundred years, either in the form of separate annual reports or in summaries for journals or societies. These reports give some information as to the prevalence of certain diseases in certain places at certain periods of time, and in this way have some historical value, but they do not show the proportion of cases of disease or death to the living population in which these occur, and very few of them give the data by sex and age in the manner required by the statistician. Some of these calculate death-rates with reference to the total number admitted during the year, others to the total number treated, which includes those remaining on hand at the beginning and those admitted during the year, and others to the total number disposed of during the year by discharge, transfer, or death. A few of them give the average daily number under treatment during the year and the average number of days' treatment for each case, sometimes making a distinction of sex, but almost never of race or age.

Comparisons of gross death-rates of different hospitals, however calculated, are of little value for the purpose of determining either the sanitary condition of the place, the skill of the medical staff, or the merits of the particular system of treatment, owing to the great variations in the class of patients admitted. Of course, the statistics of hospitals for special classes of diseases can only be compared with those of the same kind, and, even for general hospitals, the fact that the gross death-rate of one is higher than that of another proves very little.

In a paper by Dr. Guy on the rate of mortality prevailing in the general hospitals of London, he compares the death-rates of King's College Hospital, with which he was connected, for the first five years of its existence, 1840 to 1844, with the five years from 1857 to 1861. During the first period it was an old building, in a bad locality, and greatly crowded, and without any reputation as a hospital or as a medical school. During the last five years it was in a new building, with excellent sanitary arrangements and with an excellent reputation. He calculated the death-rates on the number of admissions to the hospital. The rate for the first five years was 8.4; during the last five years it was 10.85. He concludes that a higher rate of mortality may be due to causes very different to sanitary defects in the building and want of skill in the medical staff, and that in a large city, in the case of a hospital enjoying similar sanitary advantages, the rate of mortality is mainly determined by the reputation of its hospital staff among the public at large and among its own pupils, which reputation influences the proportion of grave and dangerous cases which are sent to it.

In comparing hospital death-rates it is now generally agreed that it is best to make use of the death-rates in relation to the total number of persons disposed of by discharge, transfer, and death for a series of years. Comparison of the number of deaths with the admissions only, is apt to give very misleading results. A better method than this is that of Bertillon, who adds to the number at the beginning of the year one-half the sum of those admitted and of those going out. It is also desirable to know the ratio of deaths and discharges to the mean population of the hospital, which is obtained by dividing the number of days of treatment by 365; but in this connection it is to be remembered that when the mortality is calculated with relation to the number of days' sojourn in the hospital, those physicians who keep their patients the longest will show the lowest death-rates.

In this connection may be mentioned a curious error contained in the hospital statistics of France for the years 1833 to 1852, inclusive. Here an attempt was made to calculate the percentage of death on the total number treated, but the way in which this was done was to add the sum-total of those remaining at the end of each of the twenty years to the number of those admitted during the respective years, giving an average death-rate of 8.3, the figures being: Number admitted during the twenty years, 8,818,501; sum of those remaining at the end of each of the twenty years, 2,204,676; making a total of 11,023,177.

Here it will be observed that a large number of patients are counted twice over, for, instead of the total remaining over at the end of each of the twenty years, there should have been taken only the total remaining at the beginning of the record, which was 99,262; so that the number of patients has been improperly increased by 2,105,414, with a corresponding improper lowering of the deathrate, which should be 10.3 per cent. instead of 8.3.

One of the earliest statements in relation to the mortality of hospitals is that in Sir William Petty's work on "Political Arithmetic," to the effect that in the year 1685 the proportion of the deaths to the cures in St. Bartholomew's and St. Thomas' Hospitals was about 1 to 7.

In the old Hôtel Dieu, in Paris, for the years 1770–80 the ratio of the number of deaths to number treated was twenty-five per cent.

In the hospitals in Paris in 1822, for over 40,000 cases the mortality was 12.5.

In the Charité Hospital in Berlin, from 1796 to 1817, twenty years, the death-rate was 16.66. In the Imperial Hospital at St. Petersburg, from 1803 to 1817, fourteen years, the deaths were 22.22 per cent. of the number treated.

I have prepared an extensive series of tables of death rates in hospitals, from which these are merely selections; but my conclusion from a careful examination of them is that they are worthless for any scientific purpose, and that such statistics are useless unless they give the death-rates by groups of ages.

The following table gives the means of comparing some ancient and modern death-rates.

Hospital.	Period.	Death-rate of treated.	Death-rate of disposed of.	Average stay in hospital.
Guy's Hospital, London	1730–40	13.80		
St. Thomas' Hospital, London	1730–40	11.10		
St. Thomas' Hospital, London	1870–76	12.15		
French hospitals	1833–52	10.30	10.50	
Charité Hospital, Berlin	1878–87	9.60	10.40	29.3
Allgemeines Krankenhaus, Vienna	1878–87	11.50	12.40	25.5
Italian hospitals	1885	10.37	11.32	
Bellevue Hospital	1875–86	.....	12.00	30.1
Roosevelt Hospital	1875–87	.....	10.80	27.5
New York Hospital	1877–88	.....	7.86	18.0
St. Luke's Hospital	1875–88	.....	11.07	39.6
City (Boston) Hospital	1875–88	.....	10.17	22.9
Massachusetts General Hospital	1874–88	.....	8.31	26.7
Pennsylvania Hospital	1874–88	.....	8.88	28.1
Cincinnati Hospital	1875–88	.....	9.26	29.3
Rhode Island Hospital	1875–88	.....	8.91	37.4

In his prize-essay on "Hospital Statistics" Dr. Steele substantially agrees with the remarks of Dr. Guy above referred to, and says that the hospital which confers the greatest benefit upon the community is that having the highest death-rate, as it is the one which admits the most critical and incurable affections. As the population of a city increases, the demand for hospital accommodation also increases, and, unless more of this is provided, the tendency is to select the more serious cases for admission, and thus to procure an increased mortality-rate.

I cannot assent to the proposition that a high mortality is any proof of the utility of a hospital, or of the skill of its staff—but it is certainly not a proof of the contrary.

The mortality of the non-accident cases averages from four to five per cent. But the fame of the hospital, the reputation of its staff, especially for difficult and hazardous operations, may tend to increase the ordinary death-rate.

An increased mortality in the surgical ward may be due to special provision for permanent residence of patients with incurable disease, such as the establishment of a ward for cancer-cases.

There have been a number of reports and discussions in statistical congresses and societies with regard to the best forms to be used in publishing hospital statistics. The following are the desiderata for hospital statistics as given by Miss Nightingale :

1. Remaining in hospital on the first day of the year.
2. Admitted during the year.
3. Recovered or relieved during the year.
4. Discharged incurable, unrelieved, for irregularities, or at their own request.
5. Died during the year.
6. Remaining in hospital on the last day of the year.
7. Mean duration of cases in days and fractions of a day.

In each of these headings the data are given for each disease, for each sex, and for each of a number of groups of ages; the primary object being to ascertain the total sick population, that is, the number of beds constantly occupied during the year for each disease, and each age and sex; 2, the number of cases of each disease, for each age and sex submitted to treatment; 3, the average duration of each disease for each age and sex; 4, the mortality of each disease for each age and sex; and, 5, the proportion of recoveries for the same.[1]

From what has been said in these lectures it will be seen that no form of hospital statistics can be considered as satisfactory which does not give the distinctions of sex and age, and this not only for the total of all the patients but for each of the several forms of disease treated. The best form for hospital statistics is probably the following :

Form of Table for Hospital Statistics.

		Total.	AGES.										
			Under 5	5–10	10–15	15–20	20–25	25–35	35–45	45–55	55–65	65–75	Over 75
Remaining at commencement	M.												
	F.												
Admitted during the year	M.												
	F.												
Discharged	M.												
	F.												
Transferred	M.												
	F.												
Died	M.												
	F.												
Remaining at end of year	M.												
	F.												
Total number of days' treatment	M.												
	F.												
Death-rate per total disposed of	M.												
	F.												

Prior to the discovery and employment of antiseptic methods in obstetrics the records of lying-in hospitals were very unsatisfactory. It is true that we have no very definite standard of death-rates in childbearing in private practice with which to compare them, but this rate is given by the Registrar-General of England as being at the rate of five per thousand children born alive for the twenty-eight years, 1847 to 1874.

The summary of the returns of the extern maternities in connection with Guy's, St. Bartholomew's, and St. Thomas' Hospitals for the twenty-one years, 1856 to 1876, comprising an aggregate of 74,580 cases, gives a mortality of 4.1 per thousand.

The largest lying-in hospital, and the oldest, is that known as the Rotunda, or Dublin Lying-in Hospital. In 198,481 cases of confinement in that hospital, the death-rate was 13.9 per thousand.[2] The following table is of interest in this connection :

[1] See paper on Hospital Statistics and Hospital Plans, by Florence Nightingale, Transactions of the National Association for the Promotion of Social Science, 1861, p. 554.

[2] Summarized from Dublin Medical Journal, 1869, and from Dr. Johnston's Annual Reports from 1868 to 1875.

*Table showing, for Prussia, from 1816–86, the Number of Deaths in Childbed, the Proportion per 100 to Labor Cases, to Women between 15 and 45, to Total Deaths, and the proportion per 1,000 of Population.**

Period.	Number	Per cent. of labor cases.	Per cent. of women, 15–45.	Per cent. of all deaths.	Per 1,000 of population.	1 death to each case of labor.
1816–20.	22,036	0.9454	18.82	1.430	0.402	1 : 106.0
1821–30.	44,826	0.8979	16.78	1.300	0.360	1 : 101.4
1831–40.	48,291	0.7982	13.61	1.160	0.345	1 : 112.2
1841–50.	47,506	0.7779	12.45	1.030	0.294	1 : 130.2
1851–60.	53,341	0.7949	13.07	0.950	0.302	1 : 127.5
1861–70.	64,056	0.7716	13.99	1.070	0.304	1 : 129.8
1871–75.	41,735	0.8398	14.82	1.130	0.328	1 : 121.2
1876–86.	68,942	0.5830	10.89	0.902	0.237	1 : 167.7

* Ehlers Zeitschrift f. Geburtshülfe, etc., 1889, xvi., p. 455.

It is not an easy matter to determine what may be called the normal or average mortality of women in childbirth, in order to determine the probable utility of a particular mode of managing cases of labor, as, for example, the so-called aseptic method. From the mortality statistics of the last United States Census [1] we find that in 1,577,173 births 5,646 deaths of the women are reported, being in the proportion of 3.57 per thousand births. This proportion was higher in the rural districts than in the large cities, and in negroes than in whites, as will be seen from the table :

	Total births.	Deaths from childbirth.	Deaths from childbirth per 1,000 births.
The United States	1,577,173	5,646	3.57
Rural	1,348,561	5,283	3.91
Cities	228,612	363	1.58
Whites in Southern States	723,884	2,225	3.07
Colored in Southern States	240,607	1,217	5.05

ported, or to the surroundings, or to the method of making reports and collecting data? Evidently the latter is first to be considered. In the data furnished by the census and the English registration reports, the cases attended only by midwives and wise-women are included as well as those attended by physicians, and it is among the negroes and the Germans that the proportion of cases thus attended is the greatest. Moreover, in the cities where there is a regular registration of deaths upon physicians' certificates there is less tendency to give the vague term childbirth as the cause of death than in the rural districts where the cause of death is returned by non-professional persons; but this does not apply to England, and it is not probable that it greatly influences the results in this country.

The deaths reported in the census as due to childbirth are those which occur during or soon after labor, including those due to hemorrhage, exhaustion, acute uræmia, etc., while those which occur at a later period may be reported as due to peritonitis, septicæmia, etc., although the physician in reporting the results of his private practice would include all these as deaths due to labor.

While the physician will usually consider only the relation between the number of cases of labor and the number of deaths in childbirth, the vital statistician will study the relations of deaths in childbirth to the number of women living between the ages of fifteen and fifty years, or to the total number of deaths from all causes. The figures of the last United States Census show that of every 100,000 women between the ages of fifteen and fifty living in our large cities, 16.21 died in childbirth during the year, while in the rural districts the corresponding figure is 51.58. The following table shows the ratios in relation to deaths of women from all causes, with certain distinctions of locality and race :

Table showing, for Rural and Cities, for White and Colored Females, and for Females of Irish and German Parentage, the Proportion of Deaths from Childbirth and Abortion in 1,000 Deaths of Females from Known Causes.

Grand Groups.	Rural.		Cities.		White.		Colored.		Irish Parentage.		German Parentage.	
	Childbirth.	Abortion.	Childbirth.	Abortion.	Childbirth.	Abortion.	Childbirth.	Abortion.	Childbirth.	Abortion.	Childbirth.	Abortion.
1. North Atlantic Coast region	9.3	0.7	6.3	1.0	....	...	....	...	12.4	0.3	11.2	1.5
2. Middle Atlantic Coast region	17.3	1.2	4.9	1.8	7.3	0.7	17.8	1.0	7.2	0.6	6.4	1.1
3. South Atlantic Coast region	32.4	1.8	1.1	....	24.5	0.9	32.9	0.7				
4. Gulf Coast region	37.3	3.0	1.2	0.4	25.5	1.0	23.5	0.8				
5. Northeastern hills and plateaus	12.6	1.5	8.5	1.2	....	...	....	...	10.1	0.3	10.2	
6. Central Appalachian region	13.1	1.3	6.7	1.3	....	...	....	...	21.7	0.6	15.1	
7. Region of the Great Northern Lakes	23.6	2.7	6.7	1.2	....	...	....	...	26.5	1.5	27.6	1.0
8. The Interior Plateau	17.2	1.2	3.5	0.2	11.1	0.3	22.6	1.0	17.6	0.4	17.0	0.4
9. Southern Central Appalachian region	15.7	2.3	....	....	16.5	1.1	13.0	1.3	....	...	....	
10. The Ohio River Belt	12.9	2.0	1.7	0.5	10.0	0.7	12.0	1.3	9.8	...	10.7	0.4
11. Southern Interior Plateau	25.9	2.7	....	....	21.3	1.1	29.3	1.5				
12. South Mississippi River Belt	36.1	4.2	....	....	33.3	1.4	37.9	2.3				
13. North Mississippi River Belt	20.8	2.2	3.9	0.5	....	...	....	...	36.3	0.8	16.7	0.5
14. Southwest Central region	26.5	4.8	....	....	24.6	2.2	34.1	2.8				
15. Central region, plains and prairies	14.4	2.4	2.8	0.7	13.9	1.1	13.6	1.4				
16. The Prairie region	18.8	2.0	....	...	....	...	....	...	19.9	0.5	30.6	0.8
17. Missouri River Belt	16.5	3.4	14.7	11.0	....	...	....	...	29.0	2.5	21.3	0.8
18. Region of the Western Plains	33.5	5.7	5.5	5.5	....	...	...	...	100.0	...	75.7	
19. Heavily timbered region of the Northwest	19.6	3.2	....	....	....	...	....	...	28.1	1.9	[illegible]	1.0
20. Cordilleran region	37.0	2.7	....	....	....	...	...	...	33.1	...	13.3	3.5
21. Pacific Coast region	29.8	1.7	3.7	1.0	....	...	....	...	33.7	...	15.4	
Total	19.5	2.3	4.7	1.2	13.9	0.9	24.8	1.4	14.1	0.5	18.3	0.8

For the same year (1880) the Registrar-General of England reports the death-rate of women in relation to births as 2.07 per thousand. If now we compare these figures with those given by obstetricians and physicians, we shall find that the latter give death-rates from two to four times as great. Thus, Duncan gives the death-rate in private practice as from 8 to 10 per 1,000 births, while LeFort gives the figures from maternity hospitals as 30,594 deaths in 888,312 births, or over 34 per thousand; while Ehlers, using the statistics of Prussia from 1816 to 1886, gives the rate as from 5.8 to 9.4 per thousand.

How are we to explain these differences? Is the reported greater mortality in rural districts, in certain races, or in physicians' reports, due to peculiarity in the cases re-

[1] Report on Mortality and Vital Statistics, Pt. II., lxx.

If, then, we are to judge as to whether the death-rate in childbed in the practice of a particular physician is to be considered as high or low, we must first know whether the figures relate to hospital or to private practice, and, if the latter, whether it was in the city or in the rural districts. To obtain some standards for comparison we may use the numerous reports found in medical literature in which physicians have given the statistics of their private obstetrical practice, and compare the results with those given in the statistics of maternity hospitals, for which purpose the table on top of page 650 will be found of interest.

Suppose that for the sake of testing the relative efficiency of two different modes of treatment, or of the general progress made during a series of years in therapeutics, we take the statistics of a particular disease; which should be one having a tolerably definite train of

Deaths in Childbed in City and Rural Practice, before and after 1876.*

	Before 1876.			After 1876.		
	Cases.	Deaths.	Per 1,000.	Cases.	Deaths.	Per 1,000.
America, in city practice	9,468	52	5.49	2,261	33	14.59
America, in rural practice	13,375	79	5.90	2,994	26	8.68
America, in maternity hospitals	8,514	136	15.97	6,004	143	23.81
Great Britain, in private practice, in cities	60,487	239	3.95	3,500	14	4.00
Great Britain, in rural practice	23,170	84	3.62	2,014	15	7.44
Great Britain, in dispensaries	156,993	570	3.63	76,554	193	2.52
Great Britain, in hospitals	96,382	1,626	16.87	100,997	928	9.18
Petersburg, General and Maternity Hospital	33,747	1,423	42.16			
Vienna, Imperial Lying-in Hospital	. . .	. . .	.....	15,070	106	7.03

* For prisons and asylums the death-rates should be given for the average daily population in the institution, and not for the number of admissions or for the number of cases disposed of; but in these cases gross death-rates for the whole population are of very little use. It is necessary to have them with distinction of sex and age in order to make comparisons with the death-rates of the general population coming under the same groups.

symptoms, so as to be easily recognized. A disease which it is common to select for this purpose is acute lobar pneumonia. Suppose, now, that in a given group of cases of pneumonia subjected to one method of treatment the mortality is found to be greater than in another series of cases subjected to a different treatment, are we thereby authorized to conclude that that mode of treatment connected with the lowest mortality is really the cause of the low mortality? By no means. Before we can do this, we have to settle the character of the cases, the proportion of those in each group occurring in advanced age, or in intemperate persons, or in those affected with other diseases, or in certain races, because all these circumstances influence the death-rate. We have also to take into account the total number of cases in each group, in order to make an allowance for the probable error due to small numbers. If the two groups of cases have occurred in different localities, or have been treated in different institutions, we have then to take into account the special influences of the locality or institution, as far as it is possible to do so, and not until all these corrections have been made can we fairly estimate the relative influence of the treatment.

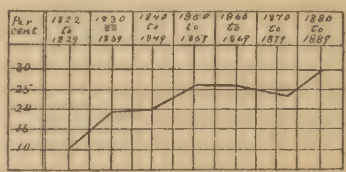
I have collected the statistics of 209,755 cases of pneumonia occurring in this country and in Europe within the last fifty years, as shown by the following table, giving an average death-rate of 21.11 per cent. The distinction of sex is given in 33,904 of these cases, showing a death-rate of 19.86 per cent. in males, and 24.68 per cent. in females.

	Cases.	Deaths.	Percentage of mortality.
In Civil Hospitals.			
German and Australian	44,952	9,868	21.95
British	3,467	770	22.20
Canada	353	91	25.77
American	6,259	1,918	30.64
India	133	41	30.82
Total	55,164	12,688	23.00
In Military Hospitals.			
Austrian (1873–82)	9,007	1,276	14.16
United States Army (1877–88)	2,430	455	18.72
British Army (Crimea 1854–57)	590	125	21.18
United States Army (1861–66), white troops	61,204	14,738	24.08
United States Army (1861–66), colored troops	16,133	5,233	32.43
Total	89,364	21,827	24.42
In the Navies.			
United States Navy (1873–88)	933	92	9.86
British Navy (1872–76)	1,670	194	11.49
United States Marine Hospital Service (1872–88)	3,454	573	16.58
Total Naval and Marine service	6,057	859	14.18
Norway (1880–85), statistics for kingdom	59,170	8,907	15.05
Grand total	209,755	44,281	21.11
Cases with distinction of sex:			
Civil hospitals, males	22,862	4,539	19.86
Civil hospitals, females	11,042	2,726	24.68
Total	33,904	7,265	

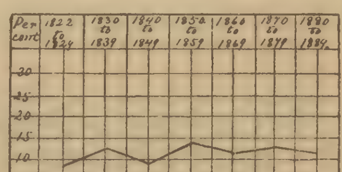
The distinction of deaths by ages for each sex is given in 24,557 cases, and from these data I have calculated the proportion of deaths to cases in each age-group, as shown by the table and diagram on next page. The immense importance of age as a factor in the death-rate from this disease is at once apparent.

In the absence of statistics of cases and deaths by ages, we can get very little information from statements of death-rates from pneumonia. For example, the death-rate in the United States Army hospitals from pneumonia from 1877 to 1888 was 18.72 per cent. of the cases treated. Was this a high or a low death-rate? We can only say that it was probably rather below the average, since the average death-rate for males between twenty and fifty years of age is 19.9 per cent. on cases treated. The need of such considerations is well illustrated in a paper by Drs. C. W. Townsend and A. Coolidge, contained in the *Medical News*, July 27, 1889, page 85.

This paper is a discussion of all the cases of acute lobar pneumonia treated at the Massachusetts General Hospital from 1822 to the present time, the figures being divided into periods of ten years, making seven decades in all. The following chart indicates the gross result in



1,000 cases. This would indicate a steady rise in fatality from 1822 to the present time. What are the circumstances which make the cases of pneumonia coming into the hospital during the last few decades more fatal than those which occurred during the first three or four decades? One of the first things investigated was the average ages of the cases of pneumonia admitted in each decade, and the results obtained showed that there was a greater number of patients over fifty years of age in the latter decades, and that the average is steadily increasing. In like manner, the proportion of cases occurring in persons of intemperate habits, or complicated with other diseases, was examined for each decade. The influence of race was also estimated, with the result that in Americans nine per cent., in Irish eleven per cent., and in other foreigners

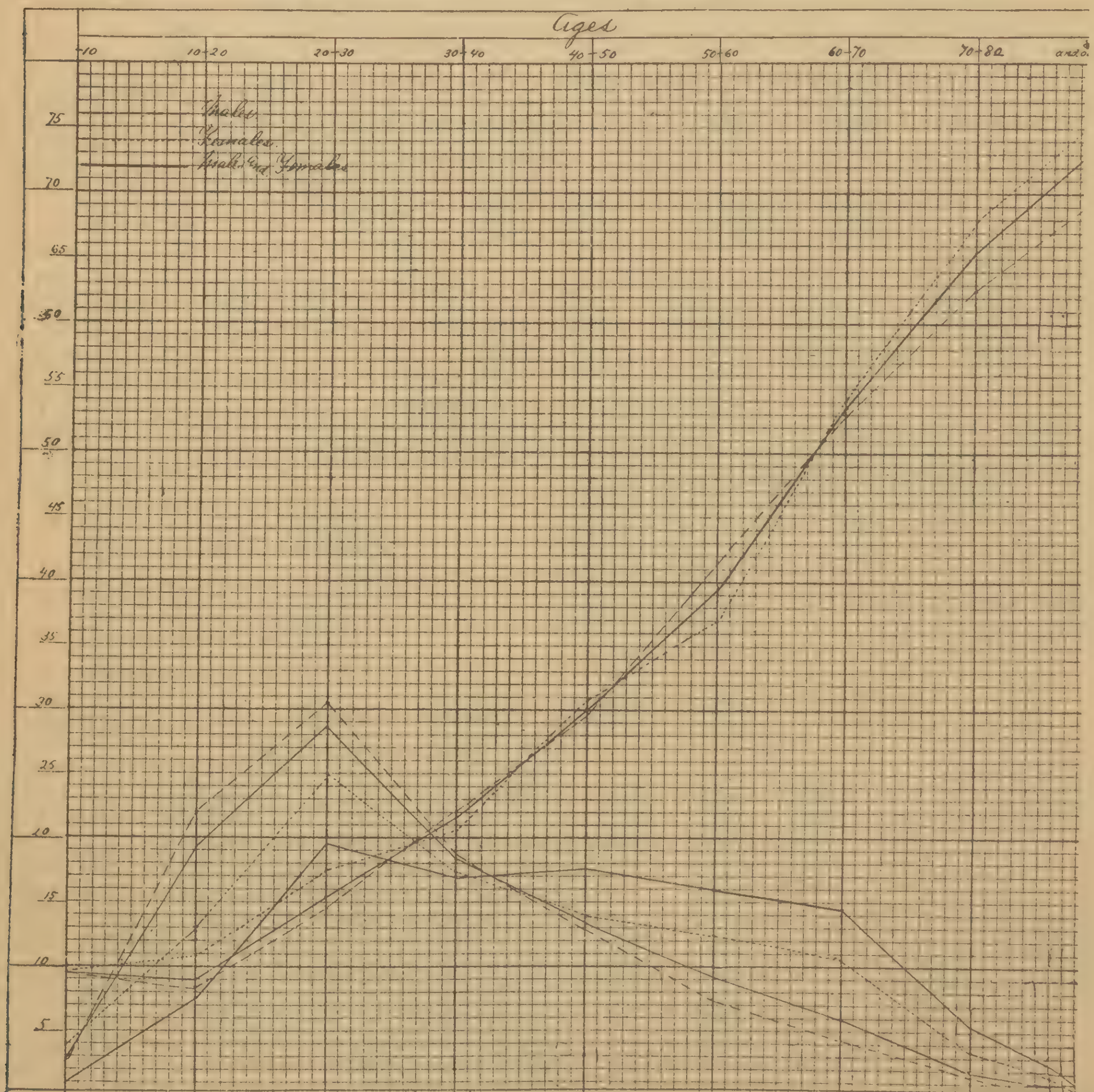


fourteen per cent. were fatal; this was omitting all fatal cases over fifty years of age who were intemperate or complicated. Now if we take the mortality and make the necessary corrections for the influence of age, or proportion of intemperate and complicated cases, we get the above diagram.

The Proportion of Deaths to Cases in Age-Groups.

	Cases.			Deaths.			Deaths by Ages to Cases by Ages per 100.			Cases by Ages to Total Cases per 100.			Deaths by Ages to Total Deaths per 100.		
	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.
6–10	445	285	730	42	27	69	9.43	9.47	9.45	2.620	3.75	2.970	1.19	1.31	1.23
10–20	3,736	980	4,716	320	107	427	8.56	10.91	9.05	22.040	12.92	19.220	9.08	5.21	7.65
20–30	5,166	1,897	7,063	753	334	1,087	14.57	17.60	15.39	30.480	25.01	28.790	21.36	16.26	19.49
30–40	3,143	1,327	4,470	685	275	960	21.79	20.72	21.47	18.540	17.49	18.220	19.43	13.39	17.21
40–50	2,228	1,036	3,264	665	316	981	29.84	30.50	30.05	13.140	13.66	13.300	18.87	15.39	17.59
50–60	1,294	954	2,248	539	353	892	41.65	37.00	39.68	7.630	12.58	9.160	15.29	17.19	15.99
60–70	726	802	1,528	387	432	819	53.30	53.86	53.65	4.280	10.57	6.220	10.98	21.04	14.68
70–80	190	268	458	119	183	302	62.63	68.28	65.93	1.710	3.53	1.860	3.37	8.91	5.41
80–90	19	34	53	14	26	30	68.42	76.47	73.58	0.110	0.44	9.210	0.36	1.26	0.69
90–100	1	....	1	1	...	1	100.00	.....	100.00	0.005	.....	0.004	0.02	.....	0.01
Unknown	18	8	26	4	6	10	22.22	75.00	38.46						
Total	16,966	7,591	24,557	....	....	...	20.79	27.12	22.75						

Diagram Showing by Sex and Groups of Ages for 24,557 Cases of Pneumonia.



— — — The ratio, per 100, of deaths, at each group of ages, to cases at same age. - - - - - - - The ratio, per 100, of cases, at each group of ages, to total cases. ——— The ratio, per 100, of deaths, at each group of ages, to total deaths.

Here, then, when we set apart the influence of the causes of death which are entirely independent of treatment, we find that there is but little variation of mortality from decade to decade, and if the influence of race were brought in, we could not infer that, upon the whole, there had been any material change in the mortality of pneumonia for the last sixty-eight years, although there have been very great variations in the treatment during that time.

The conclusions arrived at by the authors are as follows :

1. In the 1,000 cases of acute lobar pneumonia treated at the Massachusetts General Hospital from 1822 to 1889 there was a mortality of twenty-five per cent.

2. The mortality has gradually increased from ten per cent. in the first decade to twenty-eight per cent. in the present decade.

3. This increase is deceptive, for the following reasons, all of which were shown to be a cause of a large mortality :

a. The average age of the patients has been increasing from the first to the last decade.

b. The relative number of complicated and delicate cases has increased.

c. The relative number of intemperate cases has increased.

d. The relative number of foreigners has increased.

4. These causes are sufficient to explain the entire rise in the mortality.

5. Treatment, which was heroic before 1850, transitional between 1850 and 1860, and expectant and sustaining since 1860, has not, therefore, influenced the mortality rate.

6. Treatment has not influenced the duration of the disease or of its convalescence.

Suppose we try to estimate the relative value of a particular treatment of rheumatism—say, by salicylates. We find several tables in medical literature giving the results, treated by this and other methods. As a type, take the analysis of 1,200 cases treated at Guy's Hospital given by Dr. Hood,[1] in which he gives the average duration of illness, number of relapses, and number of cases of cardiac complications in 350 cases treated with salicylates and in 350 cases treated without them, and concludes that relapses and cardiac complications were more frequent under the salicylate treatment, but that the pain ceased sooner and the average length of stay in hospital was less. But the cases are not tabulated by sex, age, race, etc., so as to enable us to estimate the bearings of these circumstances on the results, nor in any tables are these results thus classified.

In the fourth volume of the "Collective Investigation Record" of the British Medical Association there is a table of 655 cases of acute rheumatism in which the details of each case are given under twenty-seven heads. Dr. Whipham analyzes these, showing how many cases there were in each sex, how many there were in each group of ages, how many in each occupation, etc., but he does not systematically attempt to group these circumstances except as regards teetotallers, temperate and intemperate persons; in other words, he does not tabulate them as a vital statistician would do so as to show how many of each sex in the first attack, in each age-group, recovered, died, had sequelæ, etc., when treated by salicylates, and how many when not treated. In attempting to treat the data by formal statistical methods it will soon be seen that they are totally insufficient in number to give definite results. For example, in temperate males having their first attack and treated with salicylic acid, of 25 between five and fifteen years of age 1 died, of 77 between fifteen and twenty-five 1 died, of 35 between twenty-five and thirty-five none died, and of 17 between thirty-five and forty-five 2 died. Of the intemperate males under the same conditions—16 in all—none died. Are we to conclude that intemperate males with acute rheumatism should be treated with salicylic acid? Not at all—it would require something like 60,000 cases instead of 600 to demonstrate anything of this kind.

Evidently the statistical data which are of the most importance differ for different diseases. If, for example, we are comparing the mortality from pneumonia under different systems of treatment, it is clear that we must have the data with subdivisions by age; and the same would hold good for Bright's disease, and, in fact, for almost all diseases, if the law of decline of vital energy with advancing years holds good. But for cancer the data of sex and race are quite as important as those for age.

An important point in medical and vital statistics is to keep the current record, or what may be called the day-book account, entirely separate and distinct from the classification or modes of tabulation. The current record must be made complete at the time, for if any items are left out they can never be replaced. But this record, once made, may be used in various systems of classification and comparison for many years afterward. If an attempt be made to put this record into the form of a classified return primarily, it is certain to be defective and will not be applicable to researches of another kind.

NOTE.—In attempting a collective investigation for the purpose of securing medical statistics everything depends upon the questions asked, and there are exceedingly few men who are competent to prepare them. As an example of how not to do it, take a set of questions adopted by a certain medical society for investigation (Middlesex East (Mass.) District Medical Society. See *Boston Medical and Surgical Journal*, vol. lxviii., 1863, p. 345). For example, "Bromide of ammonium in atheromatous affections and obesity. Dose, five grains thrice daily." "Iodide of ammonium as a substitute for iodide of potassium; said to have a more absorbent power," etc. "Galium aparine. In epilepsy. Dose, one fluidrachm thrice daily," etc.

In the reviews of the progress of medicine, of which we already have a large supply in the shape of annual addresses and centennial literature, and to which extensive additions will no doubt be made at the close of the present century, ten years hence, you will find more or less elaborate statements of the advances which have been made in diagnosis, pathology, preventive medicine, and surgical therapeutics in all its branches. Also, it is easy to show that we have made great advances in the art of relieving pain. But when we seek by statistical methods to determine what advances we have made in the prevention of death by the internal use of drugs, it must be confessed that the data are, for the most part, wanting, and that the optimist and the pessimist can propound their theories and beliefs upon nearly an equal footing, *i.e.*, that of ignorance of the real facts in the case.

It is easy to see that the statistics of fevers collected in the last century, before typhus, enteric, and relapsing fevers were distinguished from each other, are of little use now, and that modern bacteriology has destroyed, to a great extent, the value of the old statistics of tubercular diseases, typhoid fever, cholera, etc., and of the statistics of surgical operations. They have rendered some service in their day, but their value is now chiefly historical. There is, however, in existence in medical literature a very considerable number of cases which have been recorded with sufficient detail to be available for statistical treatment which they have not yet received. Death-rates in relation to number of cases of special forms of disease showing relations of mortality to sex, age, and race, are yet to be calculated, and there is material for some good and useful work in this direction.

Within the last twenty-five or fifty years, in civilized communities, the gross mortality has diminished, there has been a prolongation in the average expectation of life, and the mortality of the years of infancy has greatly diminished. But how much of this is due to preventive medicine, how much to improved conditions of habitation and to the lowering of the price of food, and how much to improved methods of treatment? Dr. Sweifel endeavored to answer this question in a lecture on "The Influence of Medical Knowledge on the Life of the People," delivered in Leipsic in 1887 ("Der Einfluss der ärztlichen Thätigkeit auf die Bevölkerungsbewegung").

Taking, as a basis for his calculations, the figures of Bavaria for ten years, and those of Saxony for thirteen years, he found that for 100,000 living population the average number of deaths from tuberculosis increased from 250 to 258; from inflammation of the lungs, from 222 to 270; from croup and diphtheria, from 98 to 123. He remarks that these are saddening figures. In spite of the sanitarians and health-resorts, in spite of ventilation, new methods of treatment by inhalation, compressed air, etc., the number of men who die from diseases of the respiratory organs is steadily increasing, and he queries whether Süssmilch was not right in his phrase "göttliche Absterbeordnung," divine law of death.

On the other hand, he shows that the mortality from

[1] British Medical Journal, December 31, 1881, p. 1119.

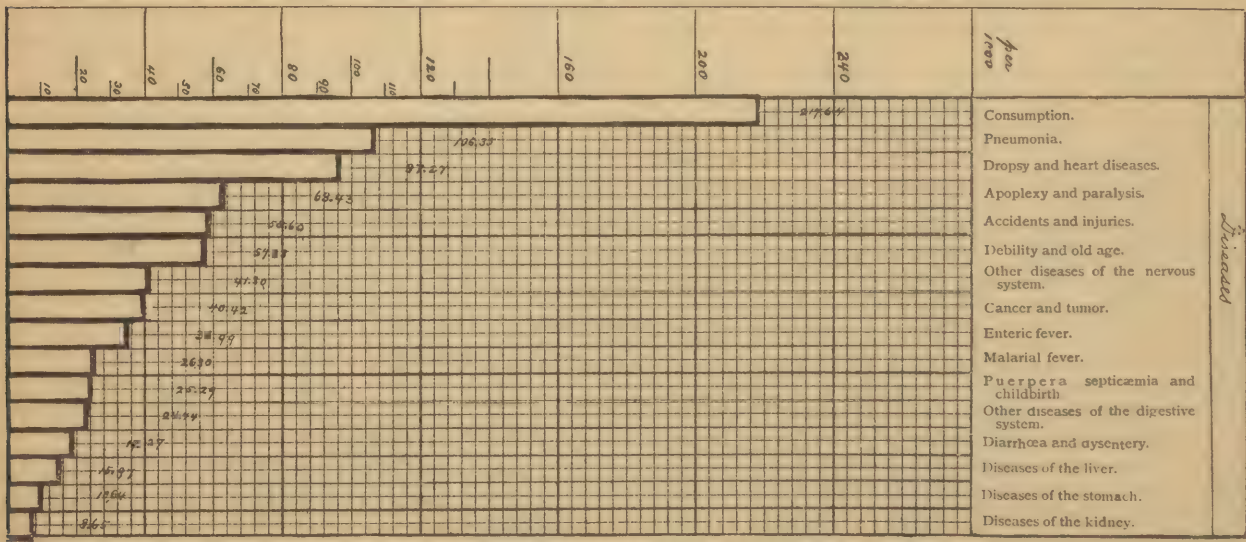
typhus has fallen from 62 to 34. But the question is, whether this is due to diminished prevalence of the dis ease or to a diminished mortality in the same number of cases of the disease due to improved medical treatment. It may be noted in this connection that the chief effect of improved sanitation appears in the lessened mortality in children under five years of age, and that it is chiefly in the mortality occurring after these ages that we are to look for the influence of improved medical treatment. In examining this, however, it is to be remembered that improved sanitary conditions affecting chiefly infants, by preserving a number of feeble and sickly children, tend to produce a higher rate of mortality in succeeding years. In cases admitting of surgical treatment, and in childbirth, there can be no doubt as to the diminished mortality in the practice of those who use the best accepted modern methods; but these methods are not yet used scientifically by half of the profession, and the results are not perceptible in the general death-rates thus far collected.

It must be admitted that the greater part of the increased expectation of life is probably due to better food, purer water, greater cleanliness, and improved methods of preventing the spread of contagious diseases. If we look at the curves representing the loss of life in large masses made in the line of prevention, and for which we have the best reason to hope for improved methods of cure after they are once established.

Total Deaths from Known Causes over Twenty Years of Age = 346,280 (*Census of* 1880).

	Deaths per 1,000 of deaths from known causes at twenty years of age and over.	Deaths over twenty years of age (unknown deducted).	Deaths per 10,000 of population of twenty years of age and over.
Consumption	217.64	75,367	28.94
Pneumonia	106.35	36,827	14.14
Dropsy and heart diseases	97.27	33,683	12.93
Apoplexy and paralysis	63.43	21,965	8.43
Accidents and injuries	58.60	20,295	7.79
Debility and old age	57.88	20,045	7.69
Other diseases of the nervous system	41.30	14,302	5.49
Cancer and tumor	40.42	14,000	5.37
Enteric fever	36.99	12,811	4.92
Malarial fever	26.30	9,110	3.49
Puerperal septicæmia and childbirth	25.29	8,759	3.36
Other diseases of the digestive system	24.44	8,464	3.25
Diarrhœa and dysentery	19.27	6,674	2.56
Diseases of the liver	15.97	5,531	2.12
Diseases of the stomach	10.64	3,686	1.41
Diseases of the kidney	8.65	2,998	1.15

Diagram showing Proportion of Deaths from Specified Diseases to 1,000 *of Total Deaths from Known Causes of Adults, Twenty Years of Age and over* (*Census of* 1880).



of people at different times and places, we see that the laws of life and death have but a narrow range of variation after the age of infancy has passed, and that improvements in therapeutics have lifted the lines but very little. They have lessened suffering greatly, but they have not greatly deferred death.

In our present state of knowledge there are certain forms of disease and derangement of organs whose tendency is to recover without any treatment, or in spite of bad treatment. There are also certain diseases and derangements which are incapable of cure by any known method of treatment. Otherwise, man would not be mortal. Between these two classes is a small number of cases of disease the result of which depends on the treatment. In order that medical statistics may give us any information in regard to this last class we have got to have some idea as to the proportion of each of the two other classes.

Out of the 756,803 deaths reported in the United States in the last census year, 355,575 were of persons of twenty years of age and upward. The above table shows the proportion of these deaths which were due to sixteen groups of causes, which produced in all eighty-five per cent. of them, and the proportions due to each of these is indicated by the diagram before you.

I leave it to you to say for which of these diseases, or classes of disease, it is most likely that progress is to be

A very good illustration of some of the ways in which lies can be told with statistics may be found in the various books and papers which have been produced in connection with the anti-vaccination controversy.

In order to understand the relations between vaccination and small-pox, it is necessary to have the death-rates from small-pox given for different periods of life—that is, by age. In this country and in Great Britain we have no data as to the deaths by small-pox by different ages prior to the introduction of vaccination, because the registration of deaths by ages has only been carried on for a little over fifty years. We can, however, for Great Britain, compare the statistics of vaccination for three different periods—the first from 1847 to 1853, in which gratuitous vaccination was provided for the people, but it was purely an optional matter with them whether they should make use of it or not; from 1854 to 1871, vaccination was obligatory by law, but this was mainly theoretical, since the law was practically not enforced; from 1872 to 1880, when the vaccination was rigidly enforced.

The table on top of page 654 shows the results of this difference.

Before the introduction of vaccination there were but few persons who did not have the disease at some time in their lives. It appeared in epidemic waves over Europe, usually at intervals of from five to seven years, being about the period of time required to accumulate, by

Mean Annual Deaths from Small-pox at Successive Life Periods, per 1,000,000 *living at each Sub life Period.*

Sub-period.	AGE.						
	All ages.	0—	5—	10—	15—	25—	45 and upward.
1. Vaccination optional (1847–53)	305	1,617	337	94	109	66	22
2. Vaccination obligatory but not efficiently enforced (1854–71)	223	817	243	88	163	131	52
3. Vaccination obligatory, and more efficiently enforced by vaccination officers (1872–80).	156	323	186	98	173	141	58
Entire period of obligatory vaccination (1854–80)	198	633	222	92	167	135	55

births, a sufficient amount of susceptible persons to enable an epidemic to make headway. Of course, then, the great majority of persons had the disease in infancy, or in early childhood, and a large proportion of these died. So that in those days the small-pox mortality, in the early years of life, was high, while those who survived were either protected from future attacks or presented a certain amount of immunity to the poison of the disease, so that the small-pox death-rate of the higher ages was then low. When vaccination came to be general, the young were protected, but were not protected as permanently and completely as would have been effected by an attack of small-pox. The result of this was that the death-rate from small-pox under five years of age fell eighty per cent., while from five to ten years of age it fell forty-five per cent., and in the older ages it may even have increased where revaccination was not systematically and thoroughly carried out. Taking the English records for 1872 to 1874, and 1877 to 1880, it is found that the proportion of deaths under and over fifteen years of age, per thousand deaths from small-pox, differs according to whether the persons were vaccinated or unvaccinated, as follows: Of a thousand unvaccinated persons dying from small-pox 672 were under fifteen years of age and 328 over fifteen. Of a thousand vaccinated persons dying from small-pox 334 were under fifteen and 666 over fifteen, the proportions being, as will be seen, almost precisely reversed under the two conditions.

The annual fluctuations of mortality from small-pox in Sweden from 1749 to 1883 are shown in the following diagrams made from figures furnished by the Swedish Board of Health.

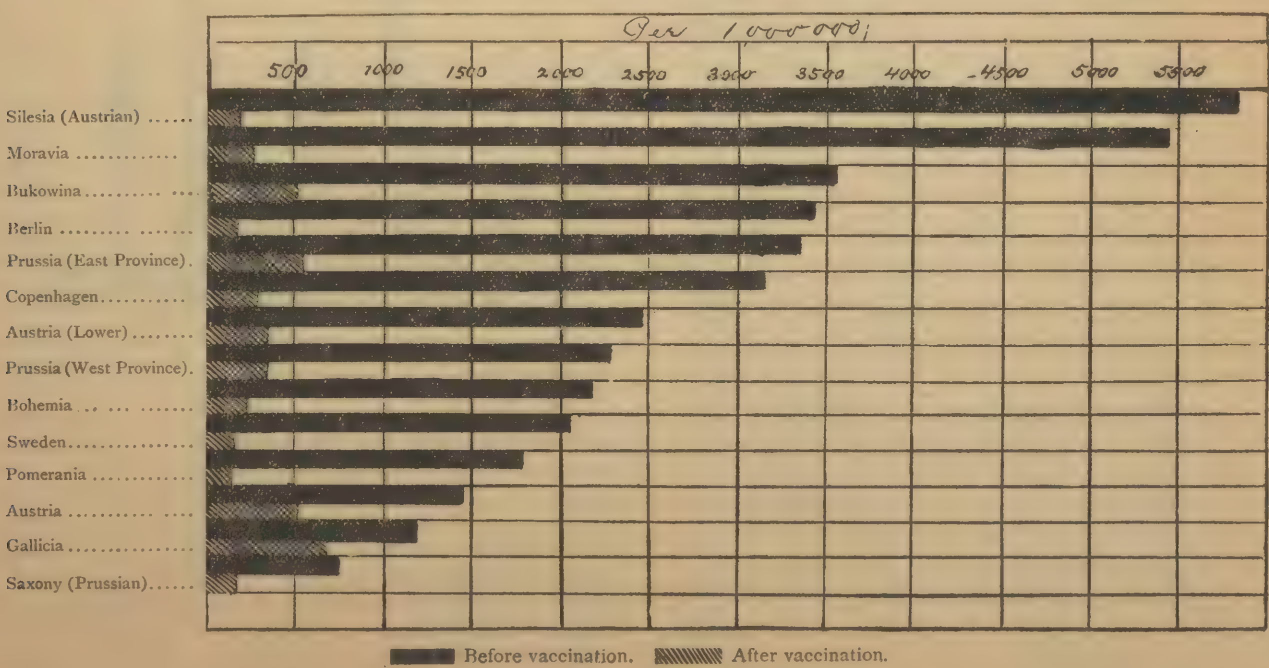
Whether the data be taken from a State, a large city, or a small town, the results are the same. Take, for example, the records of the town of Kilmarnock, in Scotland. For thirty six years, from 1728 to 1764, this place had an average population of 4,200, and a very accurate register of the births and deaths was kept. During these thirty-six years there were nine epidemics of small-pox, succeeding each other at regular intervals of about four years—just the time required to raise a fresh crop of unprotected victims sufficiently numerous to spread the contagion. The following table will give an idea of the se-

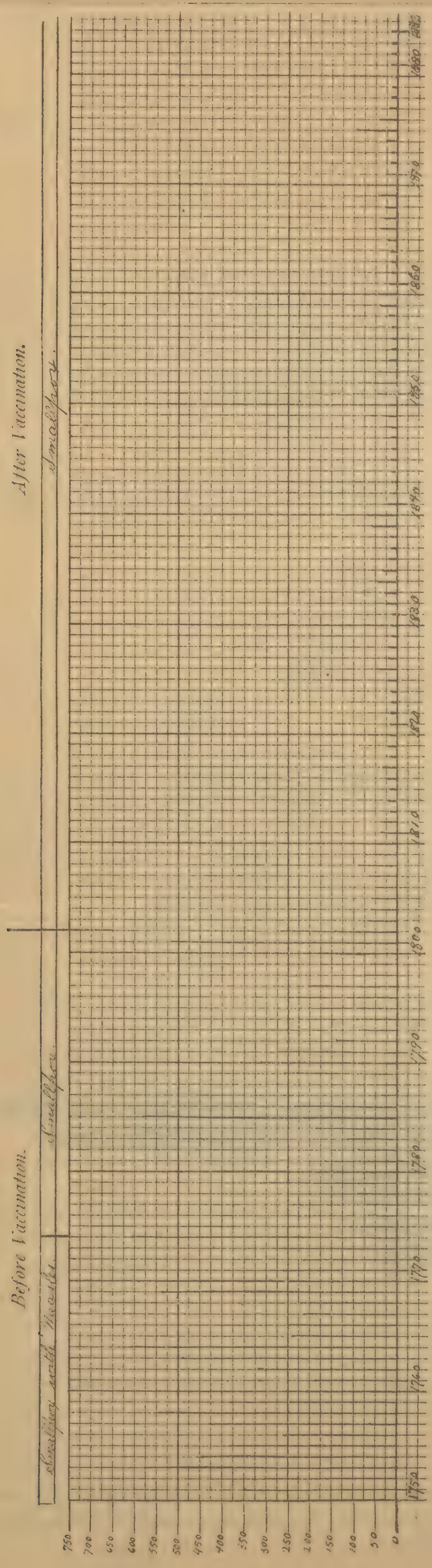
Date or epidemic.	Interval since height of former epidemic.	Total deaths.	Deaths in children born since height of former epidemic.	Deaths in children who had passed safely through one epidemic.	Deaths in individuals who had passed through more than one epidemic.
1728–29...	Unknown.	66	.	..	..
1733......	4 y'rs 5 months.	45	44	1	0
1736......	3 y'rs 5 months.	66	58	7	1
1740......	3 y'rs 7 months.	66	60	5	1
1744–45...	4 y'rs 8 months.	74	67	6	1
1749–50...	5 years.	84	79	4	1
1754......	4 y'rs 6 months.	95	84	11	0
1757–58...	3 y'rs 2 months.	45	39	6	0
1762......	4 y'rs 8 months.	66	53	11	2
Cases occurring between epidemics		14	8	5	1
Totals		555	492 Or 87 per cent.	56 Or 11 per cent.	7 Or 1 per cent.

verity of some of these epidemics. Of every thousand deaths during these thirty-six years 161 were due to small-pox; in the twenty-six years ending 1879, only 9.9 per thousand were due to it, or one-sixteenth of the old proportion. In the old days one epidemic left very few unmarked victims for the next one. Those who recovered were pitted for life, and there were very few except young children who were unscarred.

By the modern English life-table, of every 1,000 children born alive 2.3 may be expected to die of small-pox

Diagram showing for Different Countries, etc., the Approximate Average Annual Death-rate from Small-pox per 1,000,000 *of Living Population Before and After the Introduction of Vaccination.*





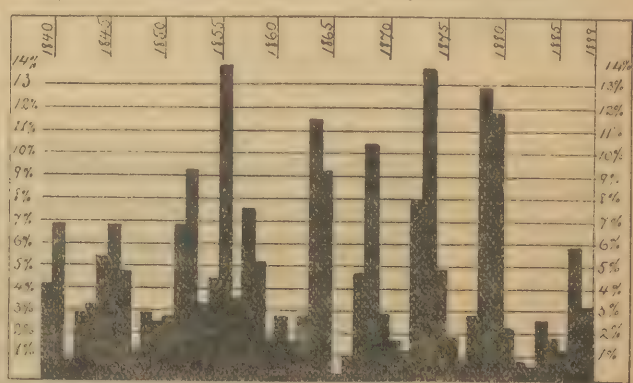
before reaching five years of age. In the old Kilmarnock table the proportion was 116 to every 1,000.

If you compare the death-rate per thousand of living population in an epidemic of small-pox occurring in a city in the United States in recent times with that of an epidemic occurring in a city in the last century, you will probably find that the death-rate was greater in the modern city than in the ancient one. Perhaps two-thirds of the people in the modern city were properly vaccinated—in the ancient city none were vaccinated. Are we to conclude that partial vaccination increases the death-rate from small-pox? Yes, for a single epidemic year; but if you take a period of twenty years or more for your comparison, you find the death-rate much lower in the vaccination than in the ante-vaccination period. Why is this? Because in the ante-vaccination period the adults had been through several epidemics of small-pox, and had either had the disease and survived, or had proved insusceptible to the virus, being, in either case, protected. The only class of the population in much danger from small-pox in those days were the young children born since the last epidemic, less than ten years before. But in the modern community, partially protected by vaccination, there has accumulated a considerable number of unprotected adults during the long periods which now elapse without an outbreak, and these increase the fuel for flame, and consequently the death-rate. Comparisons of small-pox statistics for single years are therefore almost worthless.

The results of vaccination may be indicated in another way: At the commencement of its organization, in 1761, the Equitable Society for Insurance of Lives, the oldest and most important of life-insurance companies, charged 12½ per cent. extra for all persons who had not had the small-pox. In 1781 this was reduced to eleven per cent. extra.

In 1802 it was resolved "that the directors be empowered to grant policies of assurance upon the same terms to persons who aver in their declaration that they have had the cow-pox, as to those who aver in their declaration that they have had the small-pox. But if such person shall die afterwards of the *small-pox*, then such policy shall be void." In 1823 the words, "but if such person shall die afterwards of the small-pox, then such policy shall be void," was stricken out.

Percentage of Deaths from Scarlet Fever, Providence, R. I., in Total Deaths for Forty-nine Years.

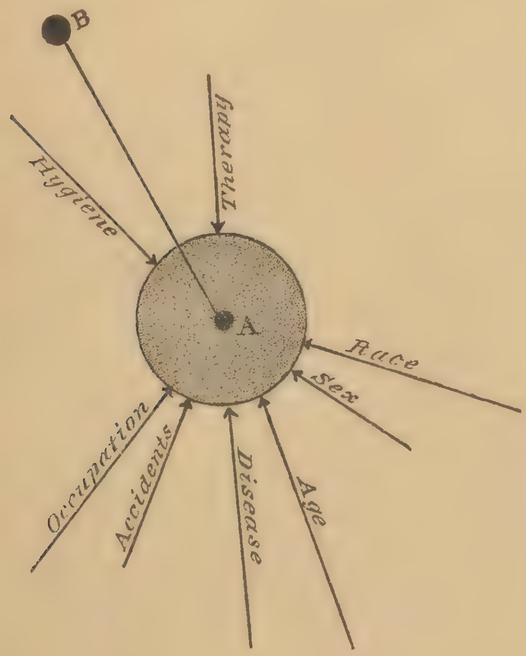


This somewhat irregular periodicity in the appearance of these contagious diseases, of which one attack affords more or less protection against a subsequent attack, is shown not only in these diagrams of the prevalence of small-pox, but also from other similar diseases; as, for instance, in scarlet fever, as shown by the diagram before you, which indicates the percentage of deaths from this cause to the total deaths occurring in Providence, R. I., for each of forty-nine years. You will see that the epidemics occur irregularly at intervals of about five or six years, with somewhat greater mortality at intervals of about ten years.

In vital statistics, as in other branches of social science,

it is not true that the effects of causes acting in combination are equal to the sum of the effects of each of the causes acting separately. Different causes of death having no relation to each other do not have a joint effect which is equal to the sum of the effects of each cause taken separately, and it is therefore difficult to bring the phenomena of vital statistics within the boundaries of mathematical formulæ. In the doctrine of this kind of averages time and number are not convertible terms.

Statistics apply to masses of men, to communities—not to individuals. We find a mass of matter moving in a certain direction with a certain velocity, and endeavor to calculate the direction and amount of the forces which have produced this result. In like manner we may consider the tendency to death in a community as a resultant of several forces as indicated in the diagram, and endeavor to estimate the influence of each of these forces in producing the result.



It is evident that we can know little of the influence which hygiene or therapeutics have had in shortening the line A B, if we know nothing of the length and direction of the other lines of force, and hence we must have the conclusions of vital statistics to make proper use of medical statistics.

In studying medical and vital statistics one is somewhat in the position of a man on the deck of a large Atlantic steamer out of sight of land and gazing on the troubled ocean. He sees many waves, large and small, apparently moving in very different directions; and it is not until he has, by careful examination and repeated comparison, learned to distinguish the ripples due to the wind now blowing, the larger cross-seas resulting from forces which were acting a few hours before, and the long, rolling swells which indicate to some extent the direction and force of the tempest of yesterday, that he can begin to understand the roll of the ship on which he stands; while to appreciate the force and direction of the great current which is sweeping with it all the troubled water and the ship itself, requires skilled observation with special instruments, and the use of charts which embody the experience of hundreds of voyages. So also in viewing the records of human life, disease, and death, the variations which are at first most perceptible are often those which are most superficial, and which give little or no indication of the magnitude and direction of the movement of the great masses beneath.

Appendix.

The most valuable sources for data relating to vital statistics, and in many respects to medical statistics also, are those contained in the "Reports of the Registrar-General of England" for the last forty years, and especially in the supplement volumes which have been issued every ten years during that period. Next to these, for matters relating to this country, come the statistics of the State of Massachusetts for the last forty years, the statistics of New Jersey for the last ten years, the mortality and vital statistics of the Tenth Census, and the statistics of Boston, Philadelphia, New York City, and of the District of Columbia. Especially valuable, also, are the vital statistics of Sweden, of Belgium, of Italy, as published for the last six or seven years; of Norway, of Switzerland, of Prussia, and of many of the large cities of Western Europe.

The following works will also be found useful for reference:

Süssmilch, J. P.: Die göttliche Ordnung in den Veränderungen des menschlichen Geschlechts, aus der Geburt, dem Tode und der Fortpflanzung desselben erwiesen, 2 Theile. Vierte verbesserte Ausgabe, genau durchgesehen und näher berichtigt von Christian Jacob Baumann. 8vo. Berlin, 1775.

Niles, N., Jr., and Russ, J. D.: Medical Statistics; or, A Comparative View of the Mortality in New York, Philadelphia, Baltimore, and Boston, for a Series of Years: Including Comparisons of the Mortality of Whites and Blacks in the two former Cities; and of Whites, Free Blacks, and Slaves in Baltimore. 8vo. New York, 1827.

Neison, F. G. P.: Contributions to Vital Statistics, being a Development of the Rate of Mortality and the Laws of Sickness, from Original and Extensive Data; with an Inquiry into the Influence of Locality, Occupations, and Habits of Life on Health; an Analytical View of Railway Accidents; and an Investigation into the Progress of Crime in England and Wales. Third edition, 4to. London, 1857.

D'Espine, M.: Essai analytique et critique de Statistique mortuaire comparée, renfermant les Monographies étiologiques des Accidents et de la plupart des Maladies mortelles, et expliquant les Lois générales de la Mortalité des Peuples par les Influences combinées des diverses Causes de Mort. 8vo. Genève, 1858.

Ansell, C., Jr.: On the Rate of Mortality at Early Periods of Life, the Age at Marriage, the Number of Children at a Marriage, the Length of a Generation, and other Statistics of Families in the Upper and Professional Classes. 8vo. London, 1874.

Bertillon: La Démographie figurée de la France, ou Étude statistique de la Population française, avec Tableaux graphiques traduisant les principales Conclusions. Mortalité selon l'Age, le Sexe, l'État-civil, etc., en chaque Département, et pour la France entière, comparée aux Pays étrangers. Folio. Paris, 1874.

Ollendorff, A.: Die periodischen Sterblickeits-Schwankungen in ihrer Bedeutung für die Medicin, Arch. f. path. Anat., etc. Berlin, 1886, cv., 110–128, 1 pl.

Bertillon, Jacques: Article "Démographie" in Encyclopédie d'Hygiène et de Médecine publique. 8vo, tome 1, p. 119. Paris, 1889.

In addition to the census and registration records we have another important source of information in vital statistics, namely, the records of life and health insurance companies. These are not as well known to physicians generally as they should be, and I wish, therefore, to call special attention to the two most valuable compilations of them now in existence, namely, the "Insurance Cyclopædia," commenced by Cornelius Walford, of which five volumes have now been published; and the "System and Tables of Life Insurance based on the Experience of thirty American Life Offices," by Levi W. Meech, published in 1881.

Field (A) Hospital at Gettysburg. 1891. See

oversize Volume VII

No. 1.

Modern surgery. 1891. See oversize

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